DOT.CBM™

Development Optimization Toolkit for CBM

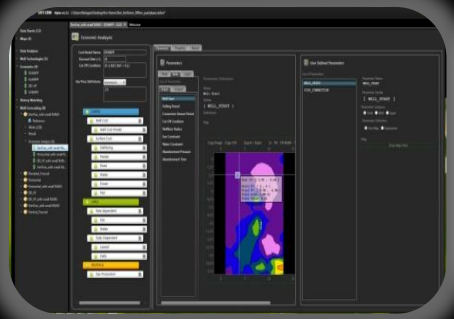
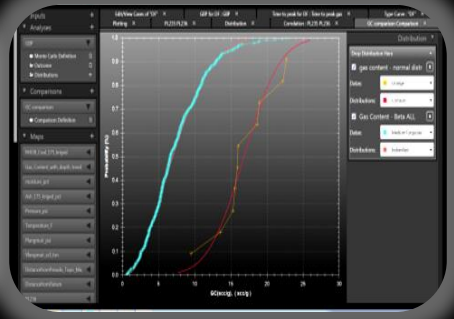
- Data Analysis for Reservoir Characterisation
- Property Mapping and Visualisation
- Production Forecasting
- History Matching
- Costs and Economics
- Development Planning Optimisation

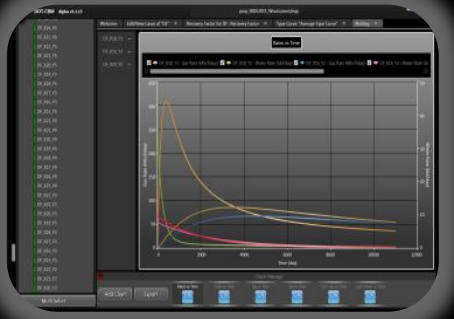
www.dotcbm.com
www.leap-energy.com

Created by LEAP Energy

DOT.CBM : Integrated platform for CBM field assessment

A user-friendly, efficient solution for forecasting, history-matching and field development optimisation



Production Forecasting

- Generate rapid full-field, static model based forecasts
- Advanced material balance production forecasting, multi-well and multi-layer
- Fast numerical scheme for transient production behaviour
- Perform uncertainty and variability assessments
- Forecast alternative well & completion concepts, with a comprehensive constraints handling capability

Field Development Planning Optimisation

- Forecast alternative drilling schedule, well technology and spacing concepts
- Automated type curve generation
- Identify optimum drilling and completion concepts
- Support decision under uncertainty

Economic Evaluation

- Perform field and sector economic evaluation using a variety of pre-defined and user-defined indicators
- Detailed and scalable complexity of cost templates.
- Development concept ranking for Field Development Planning decisions

Well Technology Selection

- Rapidly create well plans using an automated well trajectory building tool
- Automated Computation of well technology costs across the field

For more information or to arrange for a demonstration of DOT.CBM functionalities in your office please contact us at dot.cbm@leap-energy.com

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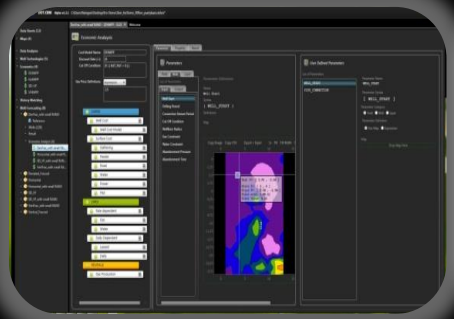
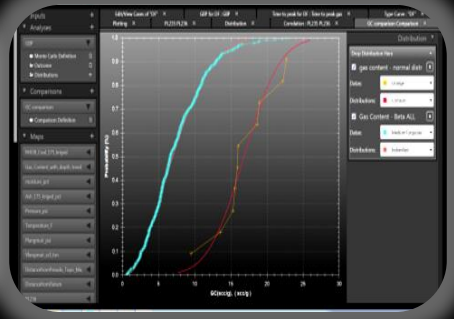

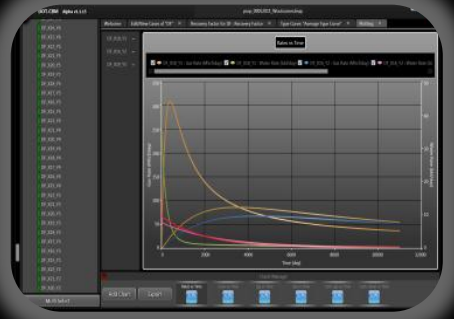

Data Analysis

- Develop property models using powerful data fitting functionalities
- Perform advanced statistical data analysis, correlations and analogue benchmarking
- Generate stochastic simulation for probabilistic volume assessment

Reporting

- Easy export of data, text, figures, tables and maps in most recognized formats
- Drag'n'drop functionality for copying data and graphics to MS Office applications

Mapping and visualisation

- Visualise, edit and generate maps of reservoir properties
- Perform upscaling and downscaling
- Automated visualisation of reservoir simulation outcomes for high-grading analysis
- GIS functionality and map overlay capability

Production History Matching

- Match pilot well production with multiple solutions
- Generate matching parameter ranges for reservoir characterisation input
- Finite-Elements numerical and Material-balance
- Multiple global search algorithm including evolutionary stochastic methods

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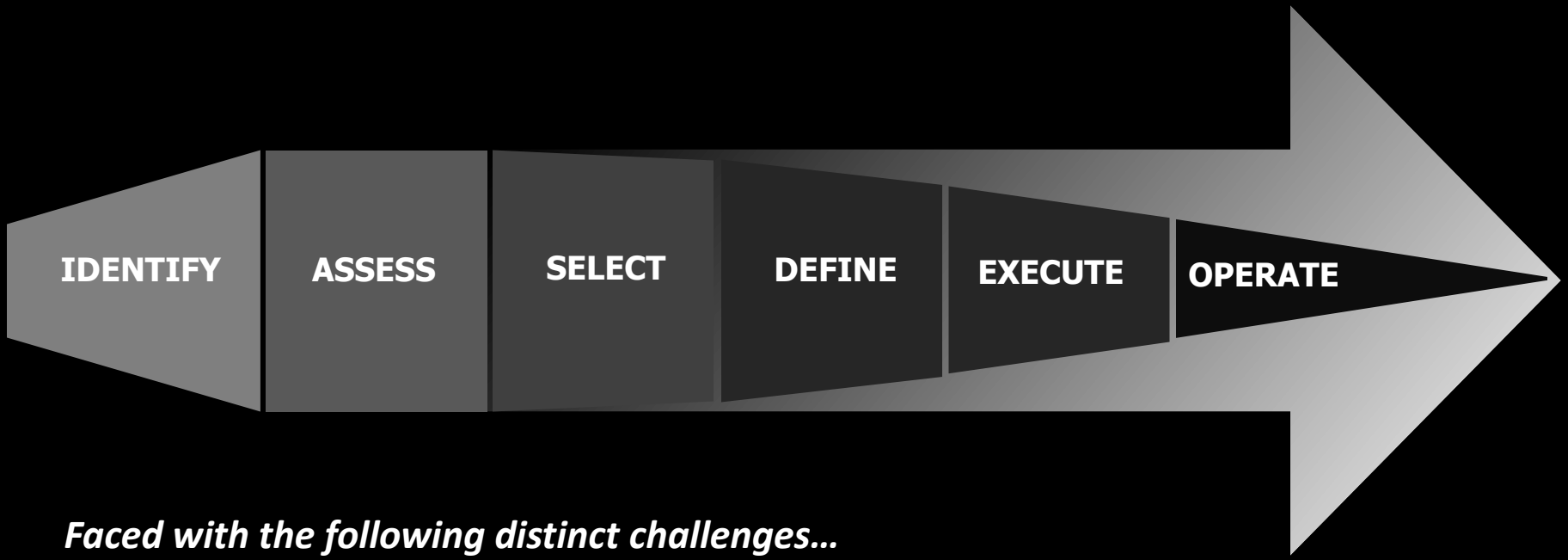
Genesis of the Tool

Through an extensive exposure to a wide range of project specific CBM challenges

Intervening over a variety of projects, at different phases of the E&P cycle



Faced with the following distinct challenges…

Field Dev. Plans

- Project areas can be 100-1000's of km2, with large well datasets
- Concept Select decisions under uncertainty and ambiguous information
- High-grade areas with impact of spatial trends

Portfolio assessment

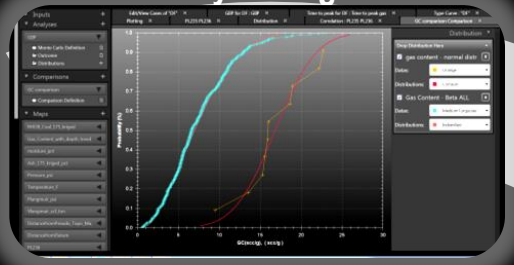
- Rapidly assess and rank assets to high-grade portfolio decisions
- Auditable link between reservoir data and type curves

Exploration & Appraisal

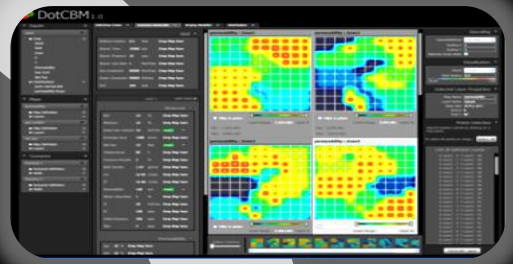
- Short-time ambiguous and variable production data
- Maximise information from pilots, determine reservoir property range of uncertainty from production

The DOT.CBM vision: Integration Integration Integration !

Reservoir Characterisation
Uncertainty management

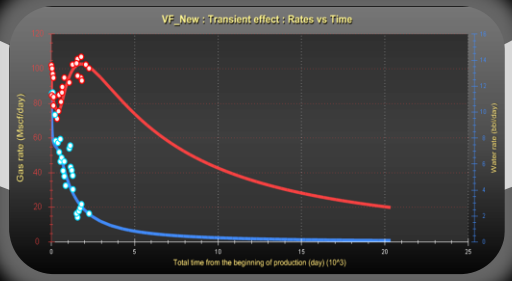


Static Modelling & Property Mapping

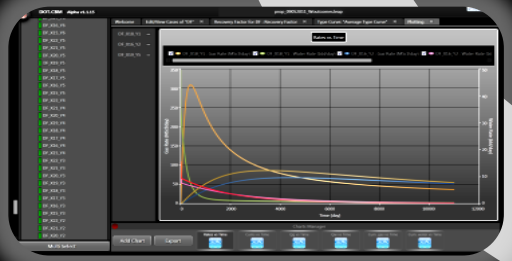


Well Concept Modelling

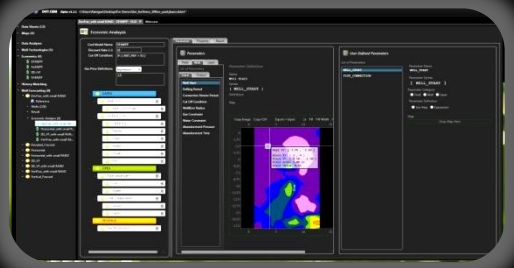
History Matching



Production Forecasting Well and Field



Economics and Development Optimisation



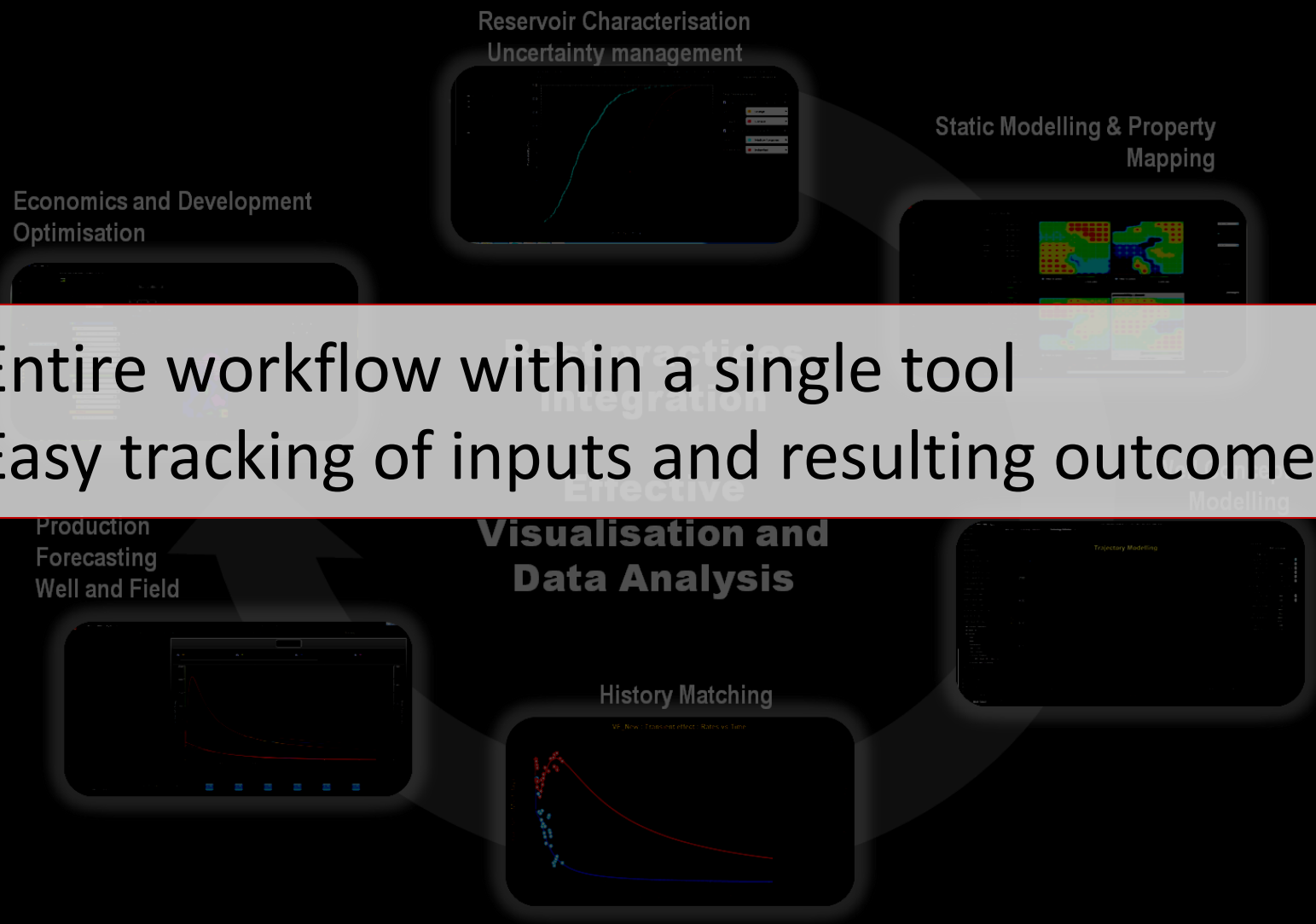
Best practices in integration

Effective Visualisation and Data Analysis

Audit Trail

Storing within the tool the Input and Output data

Generate high-quality reports and visuals



- Entire workflow within a single tool
- Easy tracking of inputs and resulting outcomes

DOT.CBM™

Development Optimisation Toolkit for CBM

FORECASTING

Generation of production forecasts at multiple levels

Single Well

Sector

Full-Field

Forecasting Engine

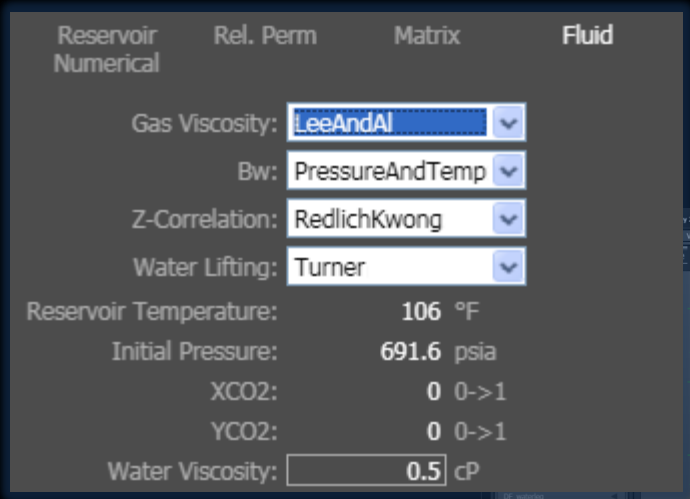
Time-efficient and powerful CBM forecasting capability

Released in this version:

- Single well, Sector and Full field
- Map based and distribution forecasting capability
- Model multi-layer reservoirs
- Variable well completion, trajectory, spacing
- Multiple PVT correlations and rock-fluid property models
- Multiple compressibility and matrix shrinkage models
- Production and Economical constraints handling
- 1D Numerical modelling option for transient flow

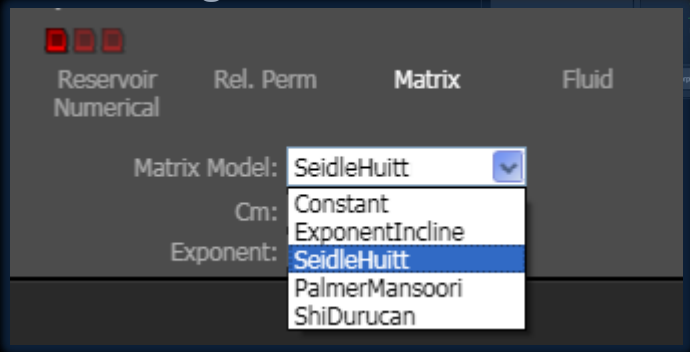
Well forecasting

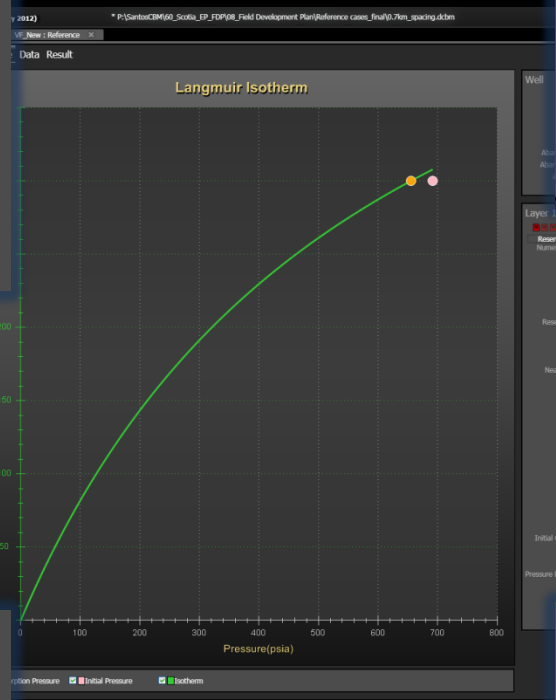
PVT model library



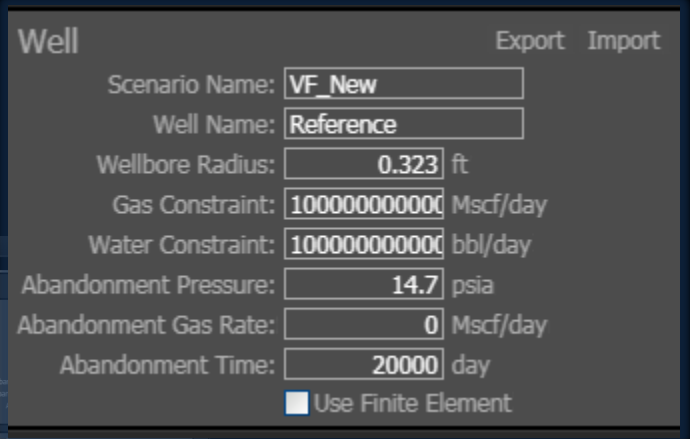
Variable gas composition (CO_2)

Matrix shrinkage modelling

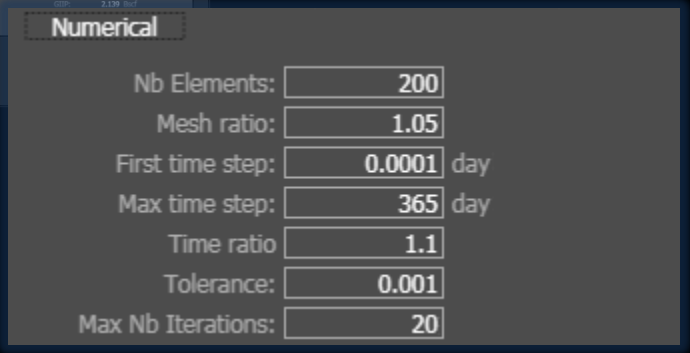




Constraint handling

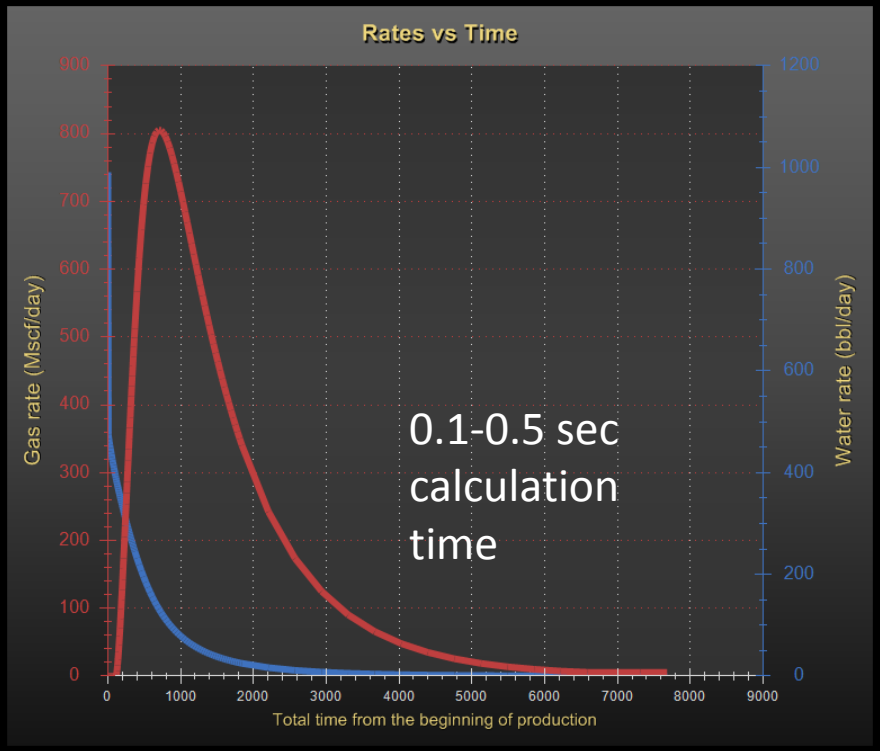


Numerical modelling option

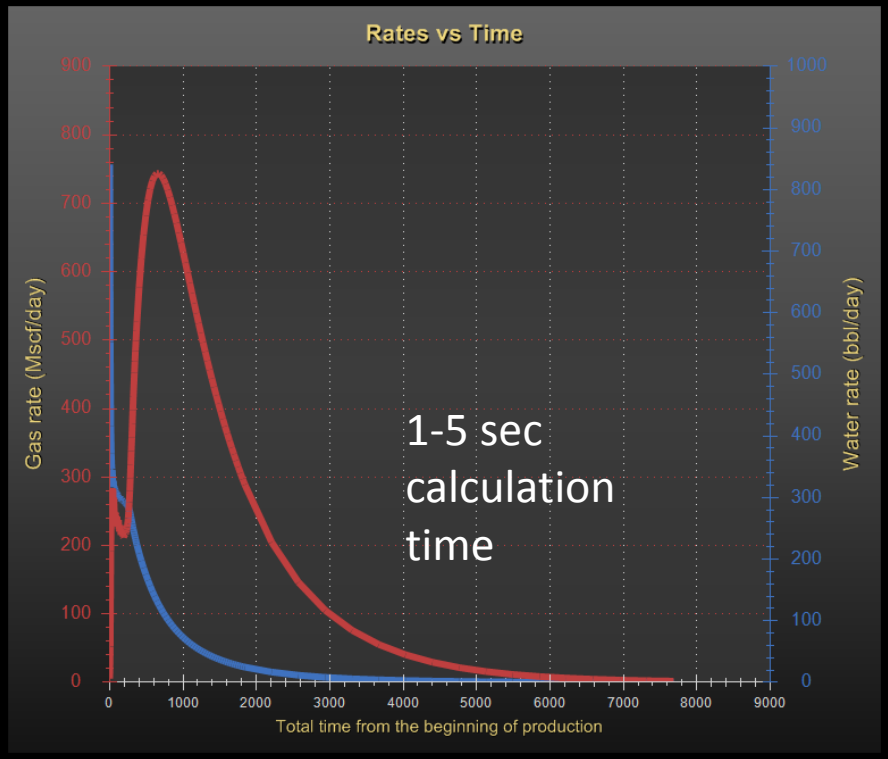


Well forecasting – numerical and material balance

Technologies developed to minimise forecasting time



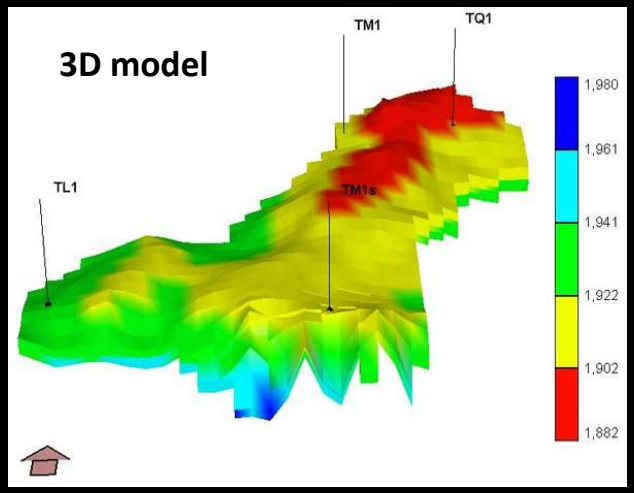
- Modified King Formulation
- Extensively tested against other commercial applications
- Multi-layer, CH4 and CO2, multi-PVT correlation, multi-well configurations and matrix shrinkage models



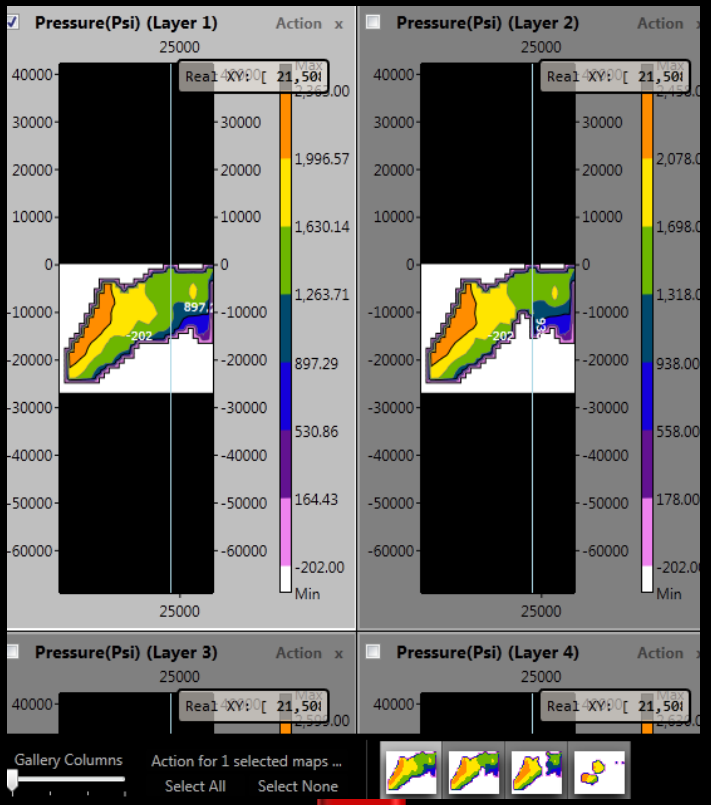
- In-house developed Finite Element numerical model
- Captures transient behaviour of tight coals
- Ideal for matching of short-term pilot production

Well forecasting – Generated from maps

Innovation in the workflow



Output maps (2D)

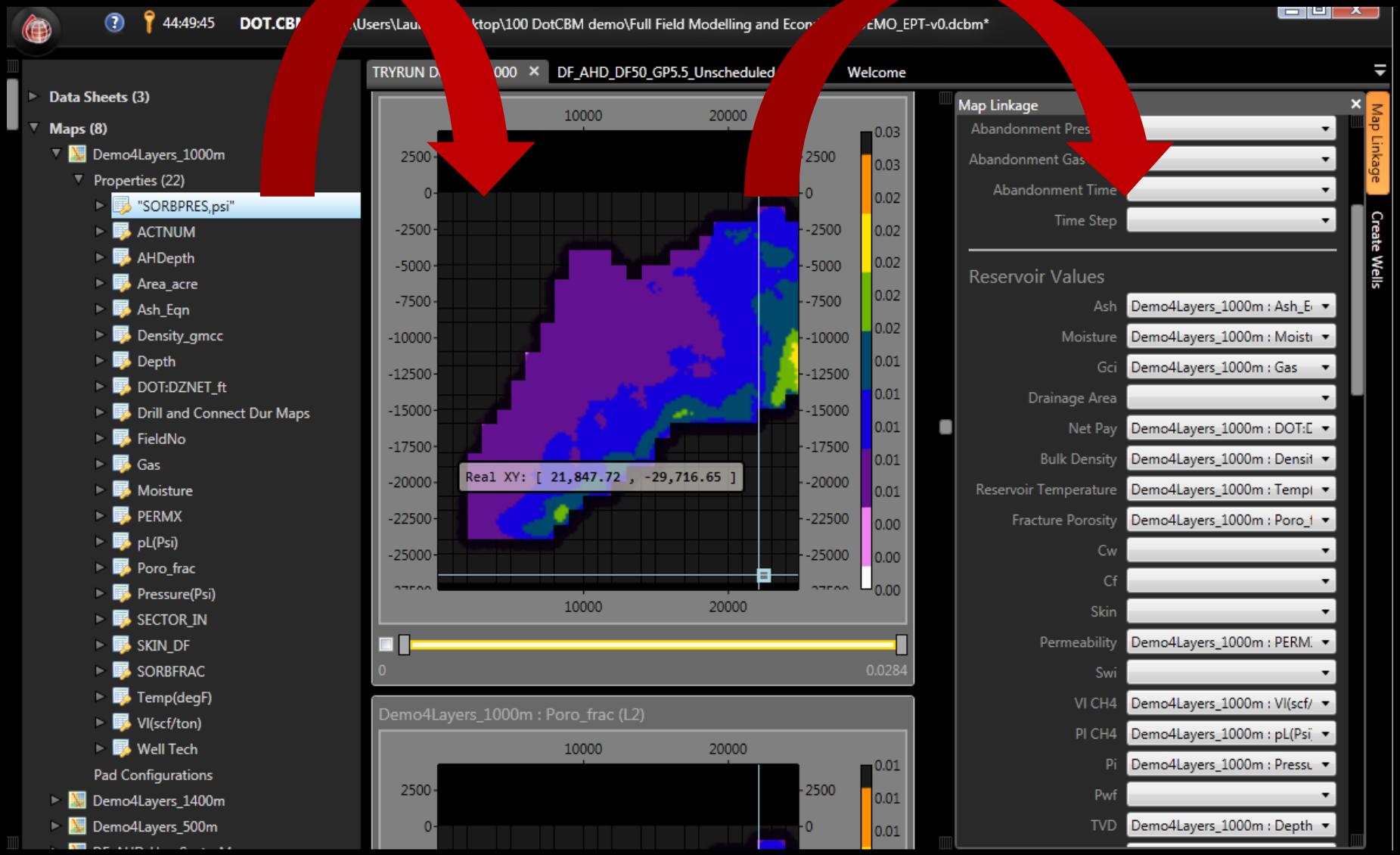


- Simplification and dramatic speed improvement
- Workflow tested vs. full 3D numerical and shows results consistency under life of field forecasting assumption
- Not a full substitute for detailed 3D studies **but designed for CSG field development planning decision making**

Generate full-field forecasts

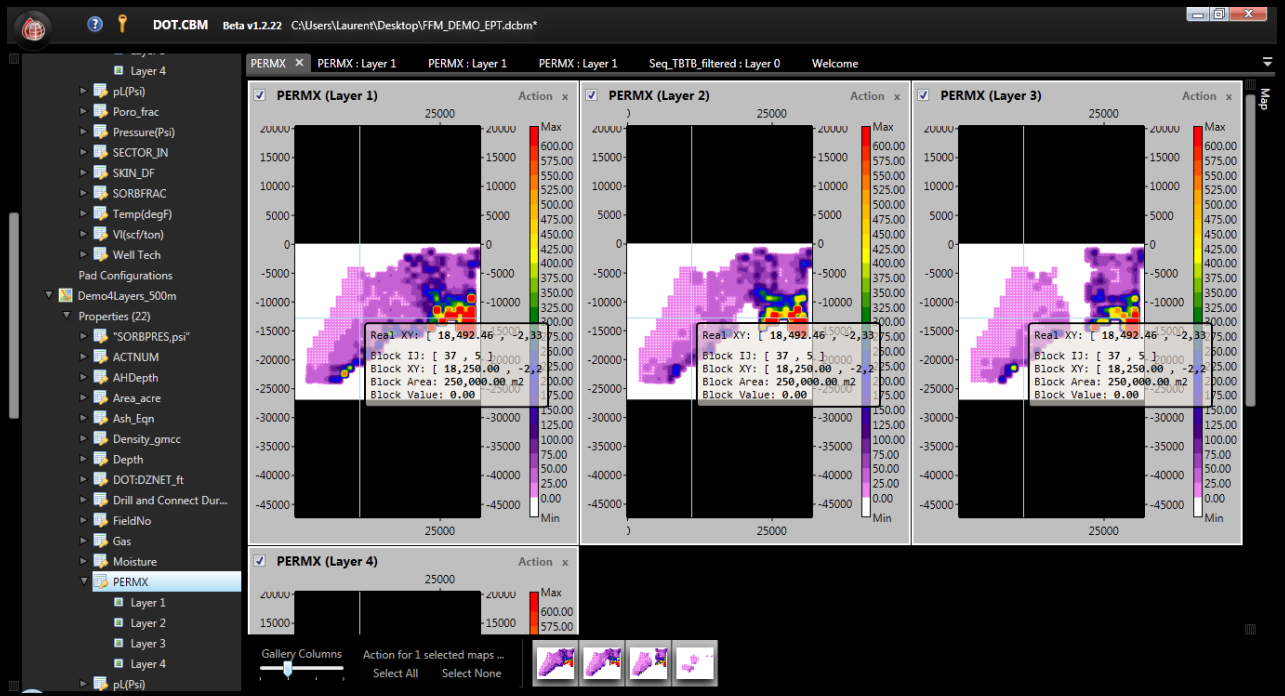
Property map from Static Model

Associated with values seen by the well (grid-block=drainage area)



Map Based Forecasting

Rapid forecast generation – multi-well set-up



- Generate forecast for field with 100's of wells in minutes
- No convergence issues
- Visual representation of spatial variability ; of inputs and outcomes

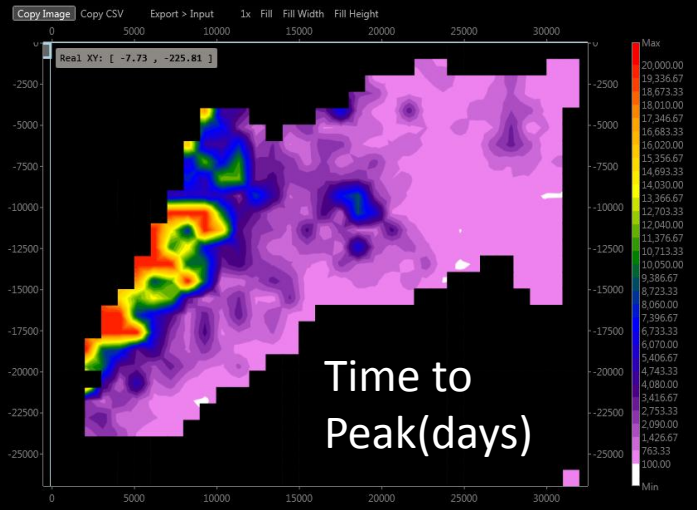
Fast computing capability – Desktop performance

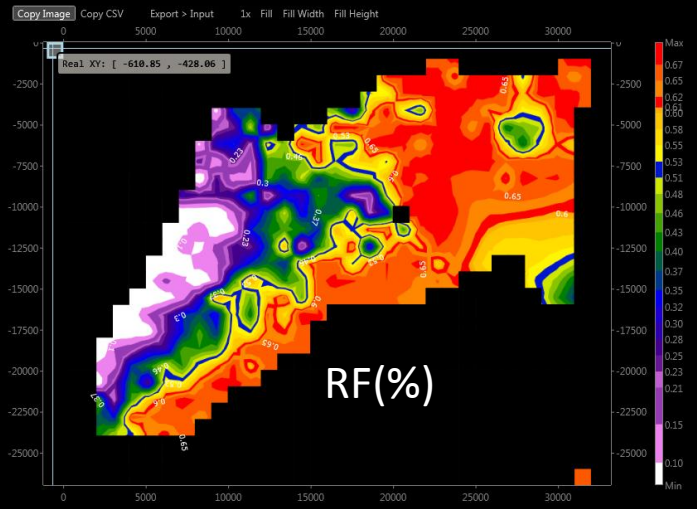
1500 wells forecast, 4 active layers, 50 years
~8 minutes

400 wells
~2 minutes

Map Based Forecasting

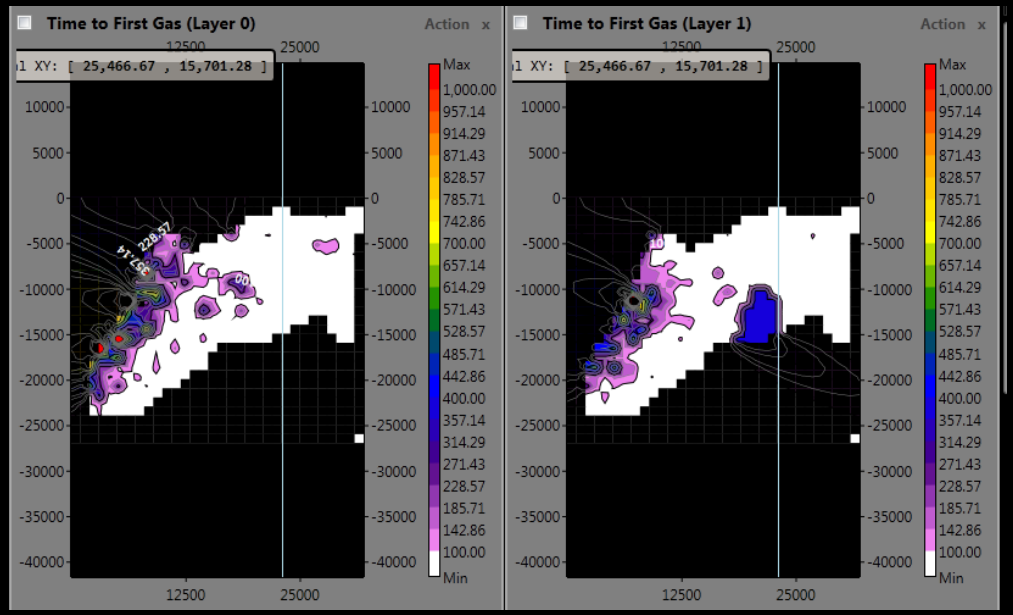
Results visualisation : AREAL TRENDS





- Visualise areal trends of computed production responses
- Recovery Factor, Peak Gas, Time to Peak (..) automatically computed

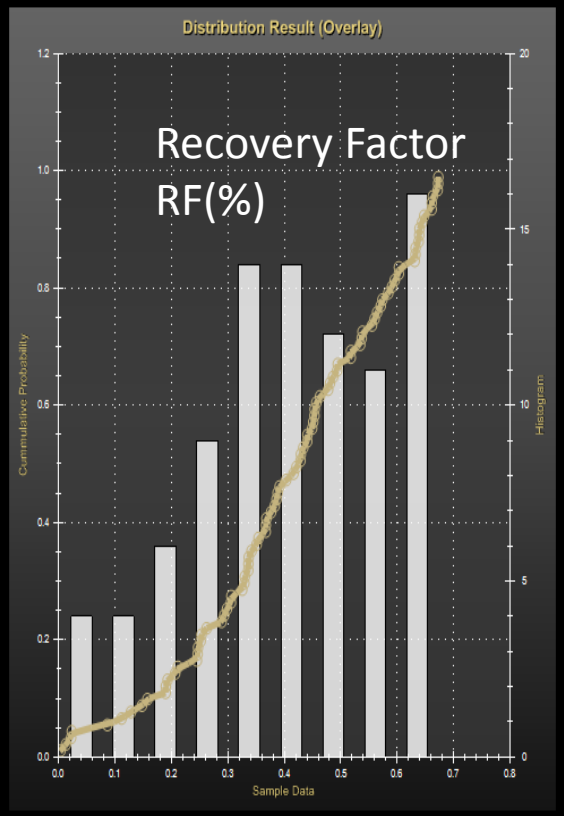
- Layer by layer results obtained

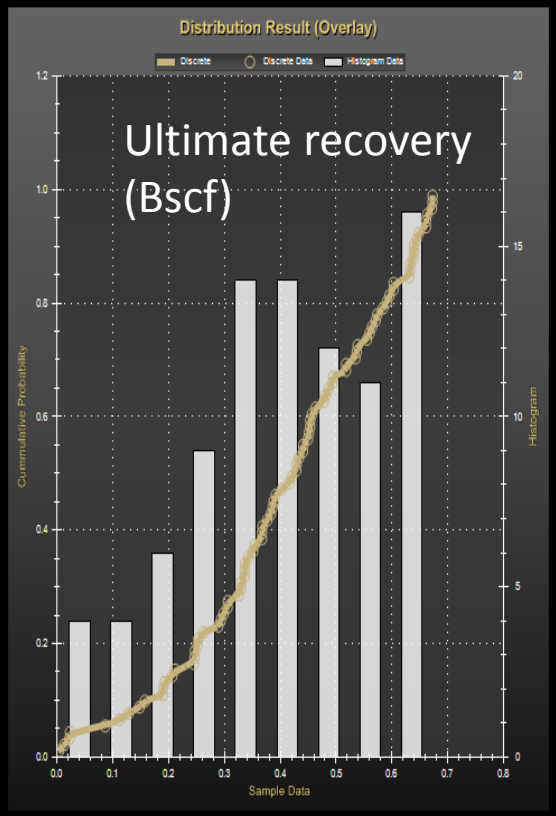


Map Based Forecasting

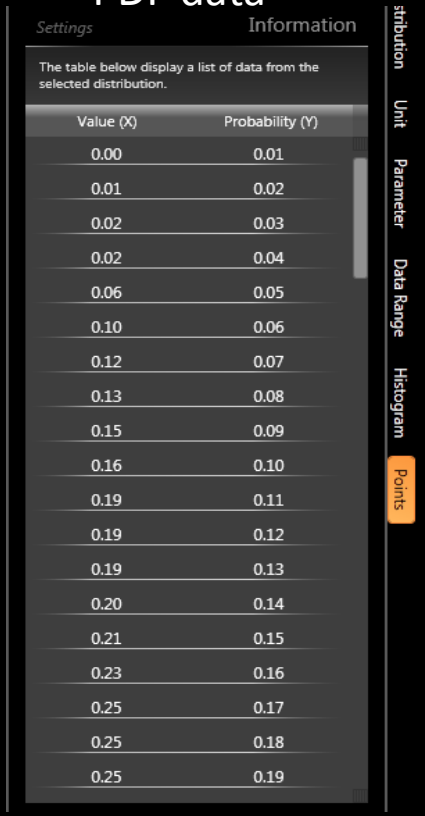
Results visualisation : Production STATISTICS

- Generate statistics of results for the field/sector/groups of wells
- Layer by layer results can be obtained
- Auto-Fitting of PDF with classic distributions: Beta, Log Normal, Normal





PDF data

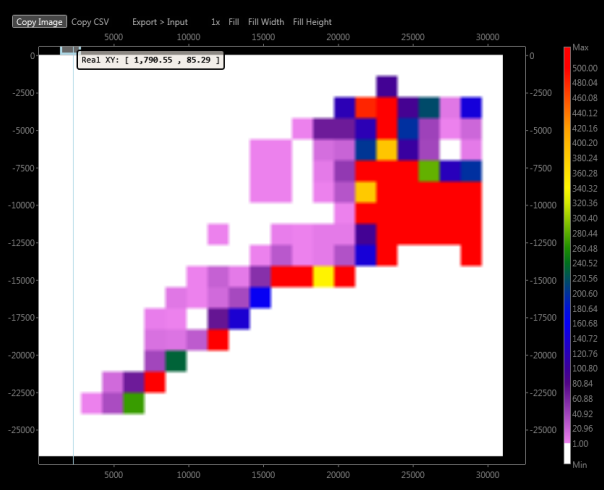


Scaling Up/Down for spacing sensitivities

Rapidly assess the results of developing assets at different spacing

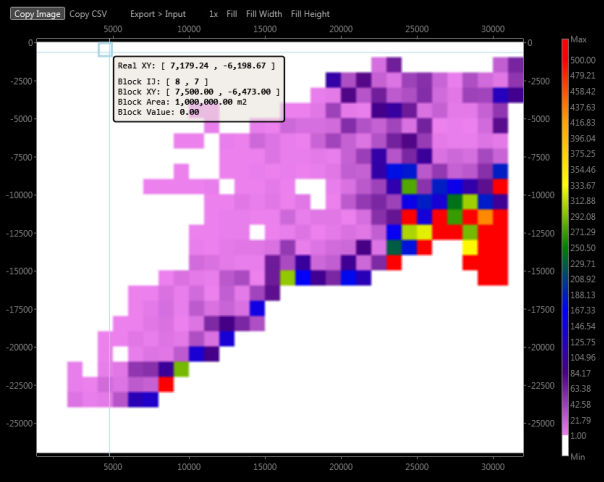
- Perform up/down scaling of loaded/created maps within the tool
- Send alternative spacing realisations to Forecast

1.4 km spacing



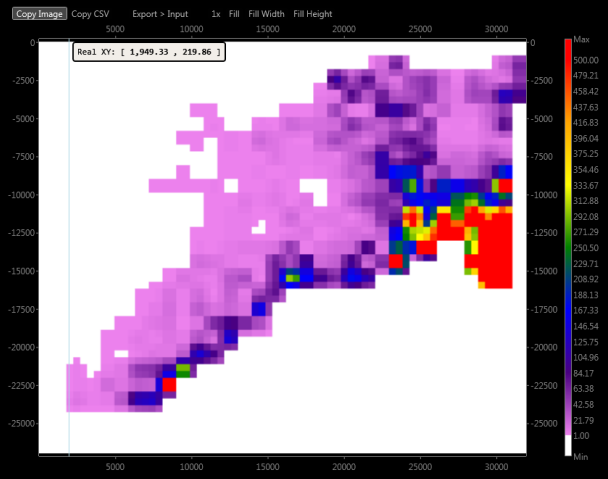
FORECAST

1.0 km spacing



FORECAST

0.5 km spacing



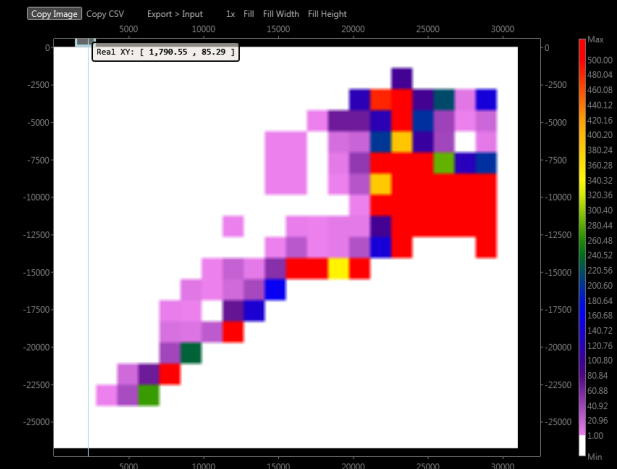
FORECAST

Scaling Up/Down for spacing sensitivities

Rapidly assess the results of developing assets at different spacing

- Visualise drainage improvement from alternative spacing

1.4 km spacing



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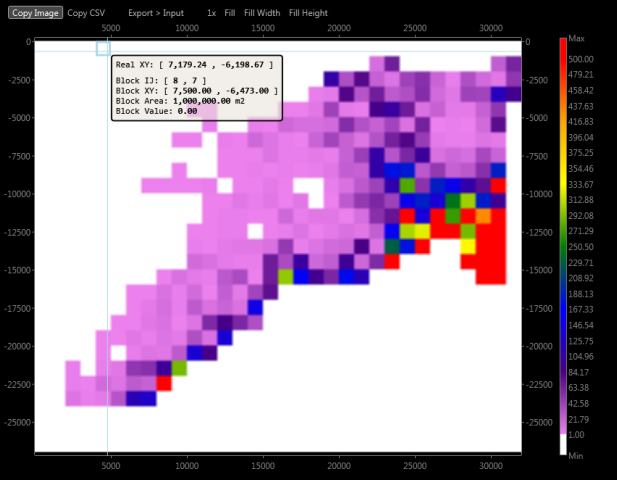

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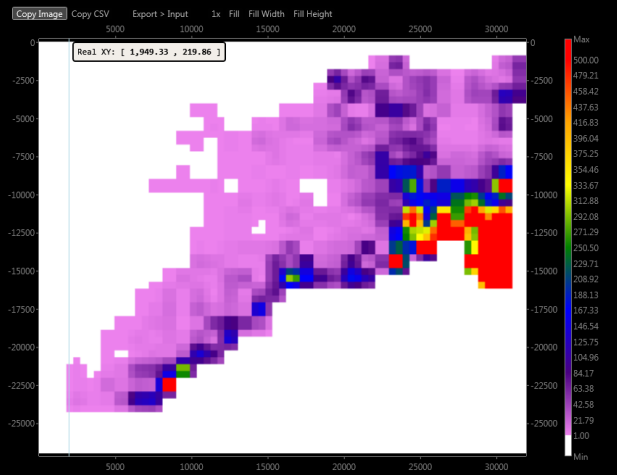
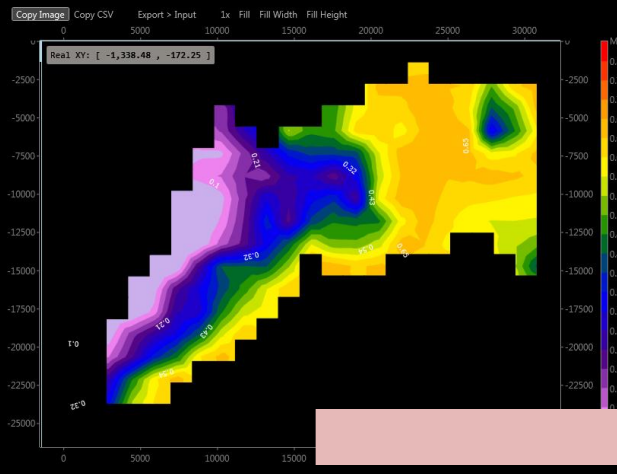
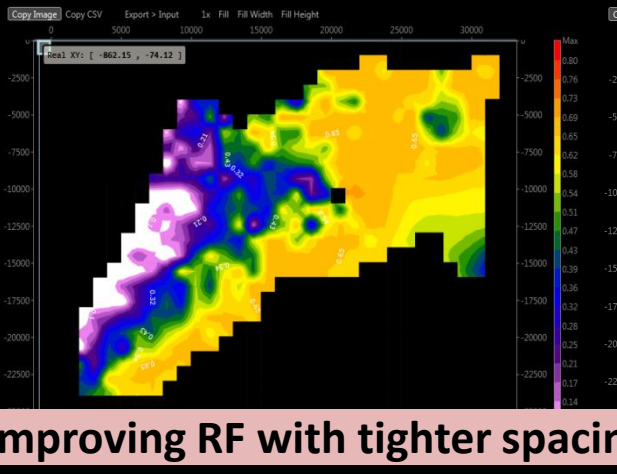
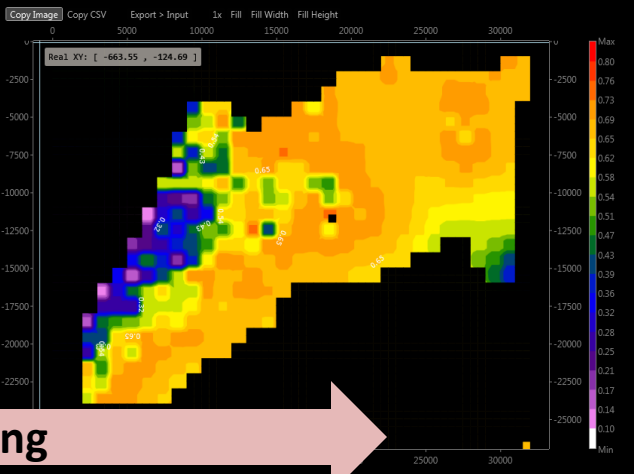








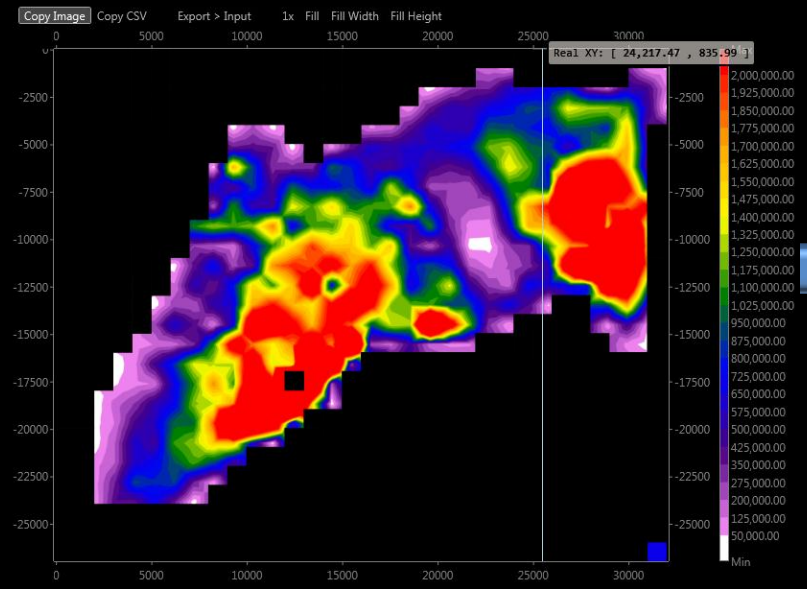
Improving RF with tighter spacing

Field forecasting – type curve generation

Generate automatically a type (average) curve for the field

Full Field – Map View (EUR Gas)

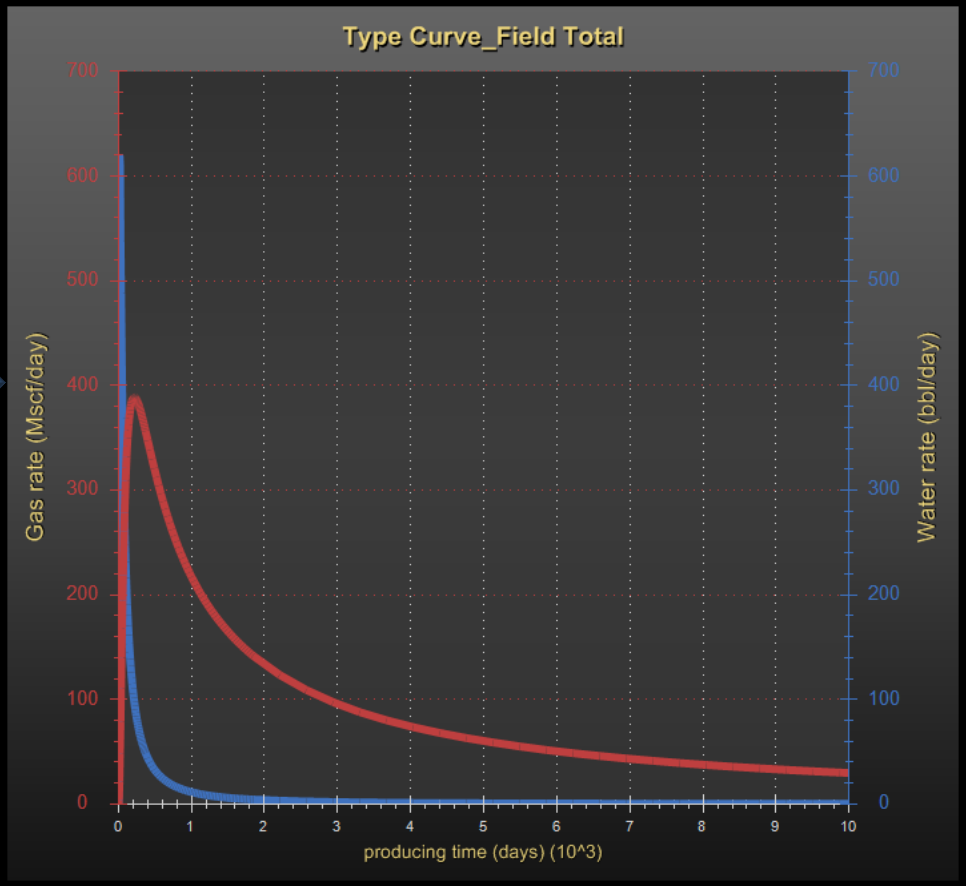
Before sectorisation



Full Field – Type Curve

Calculated as the average curve from all wells

No sectorisation



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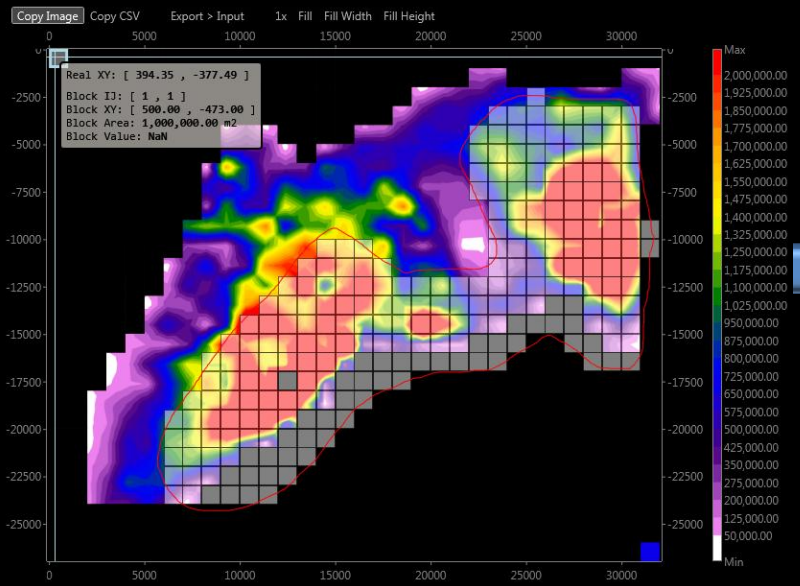
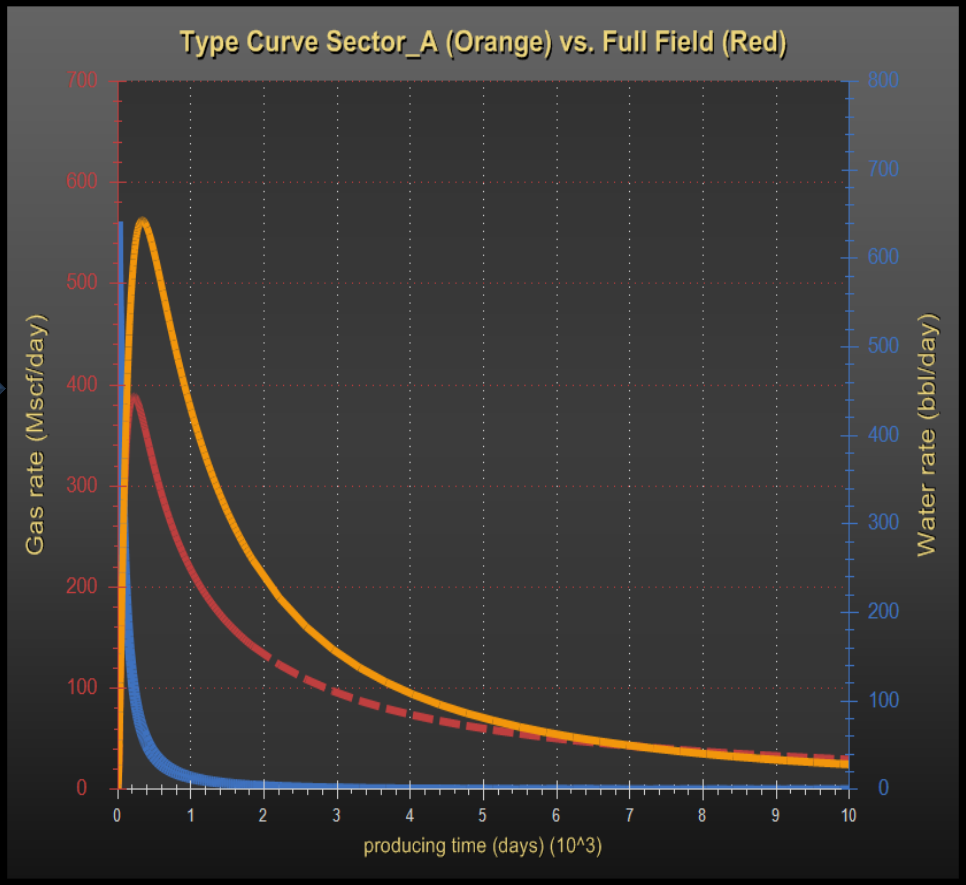
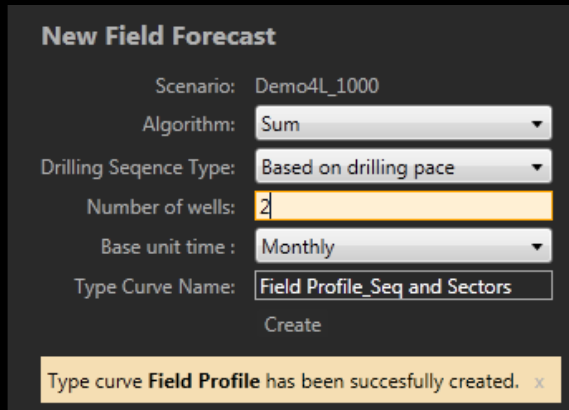


Sector_A vs. Full Field – Type Curve

Quantifies the improvement associated with sectorisation



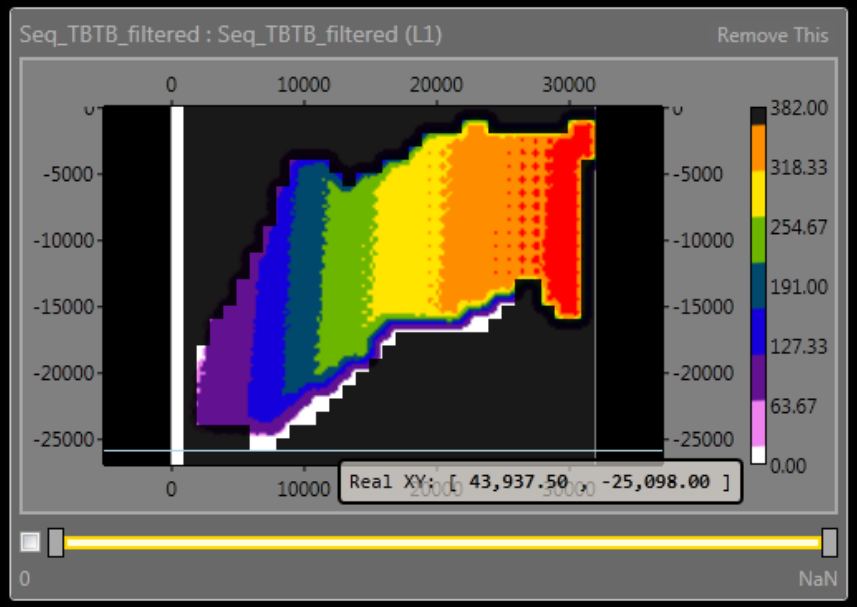
Field Forecasting – drilling sequence and schedule



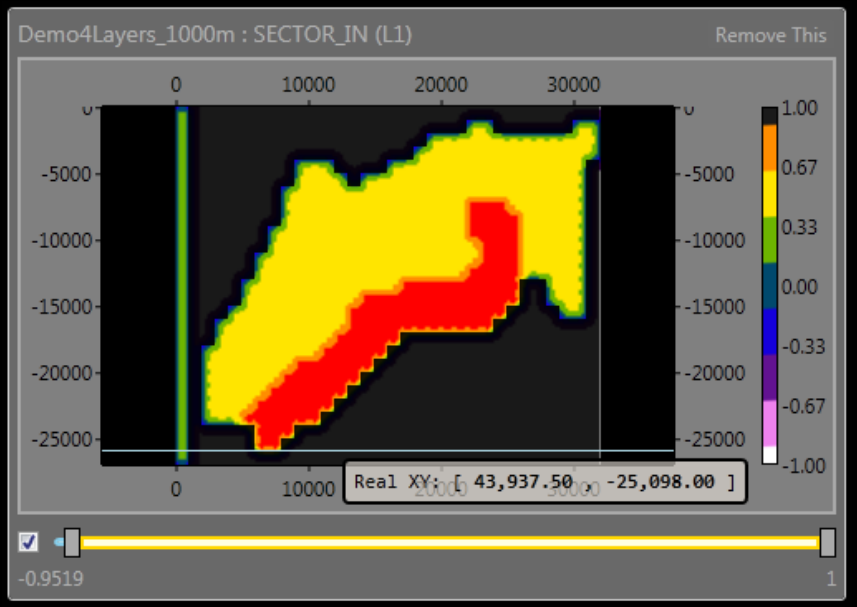
Drilling sequence definition

Customised drilling sequence for the field and sectors

Map calculator can be used to generate optimised sequences

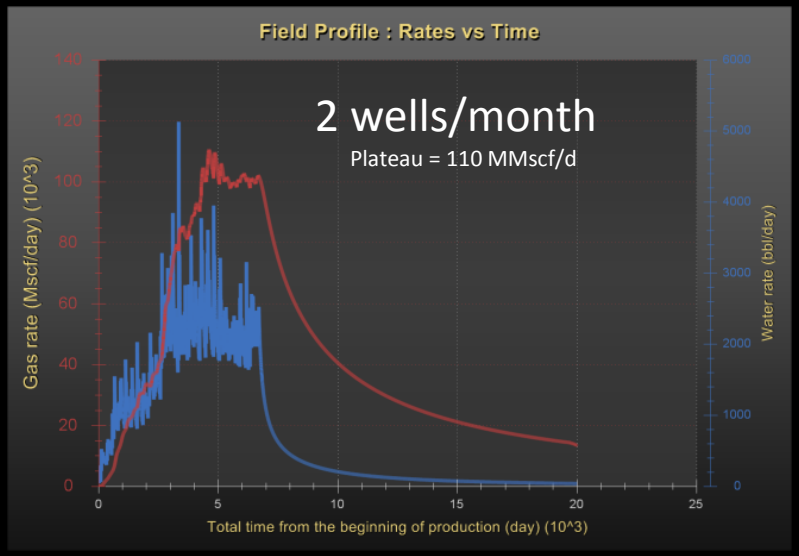


Well sequence map

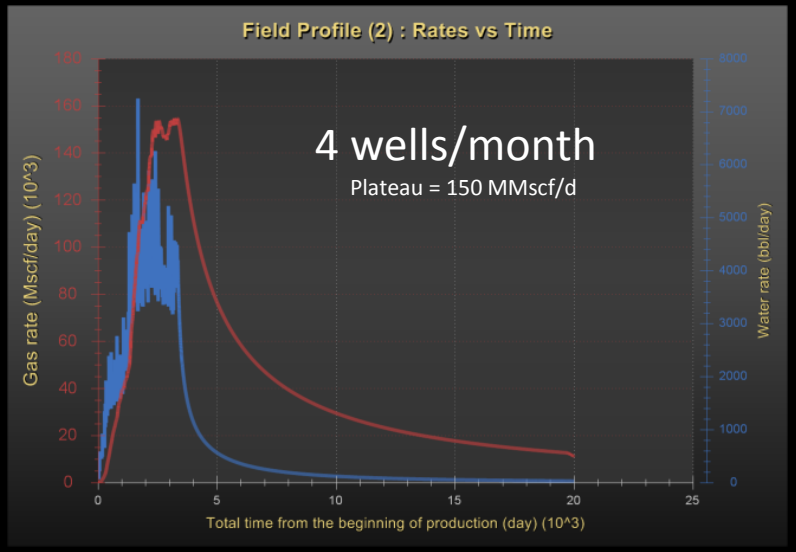


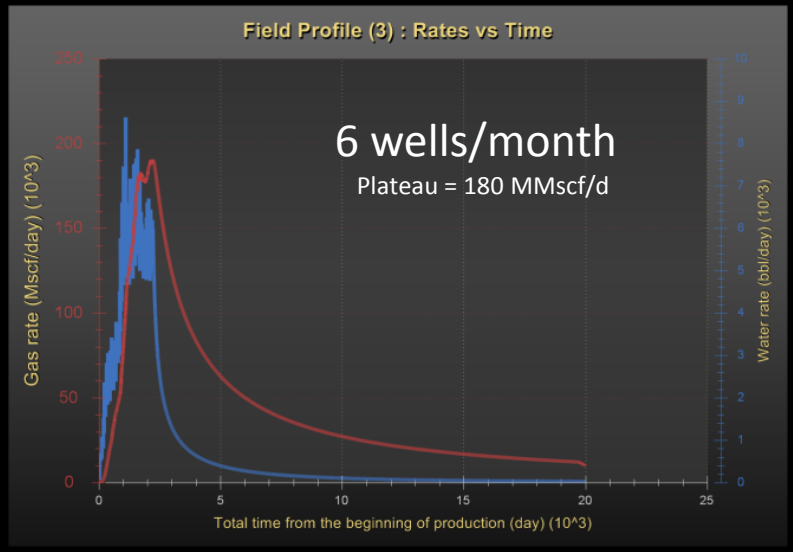
Sector definition map

Field Forecasting – drilling sequence and schedule



Generate alternative full field/sector forecasts based on drilling pace / rig availability





DOT.CBM™

Development Optimization Toolkit for CBM

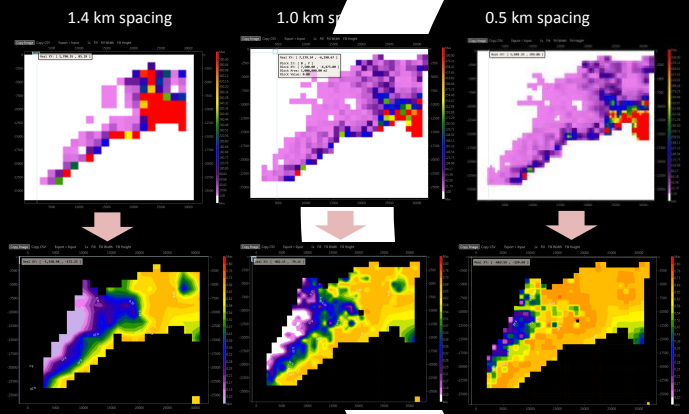
DEVELOPMENT PLANNING OPTIMISATION

Development Planning Optimisation

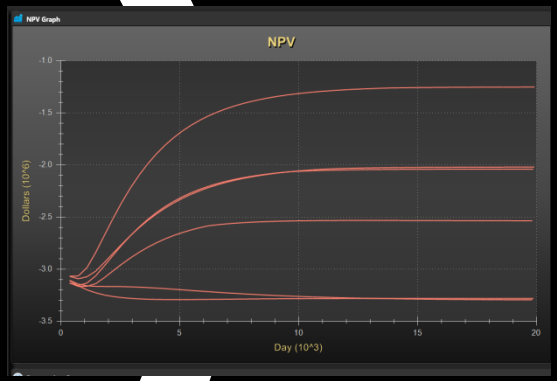
Spacing and Technology Selection

Cost Model

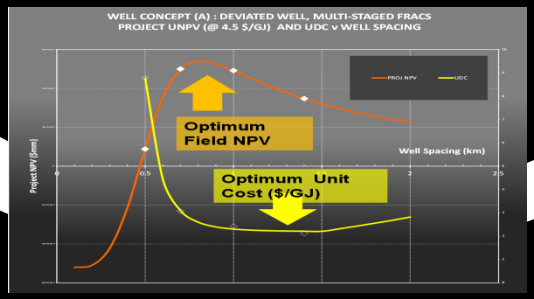
Forecasting alternatives:
Technology
Spacing



Economics or Value-metrics

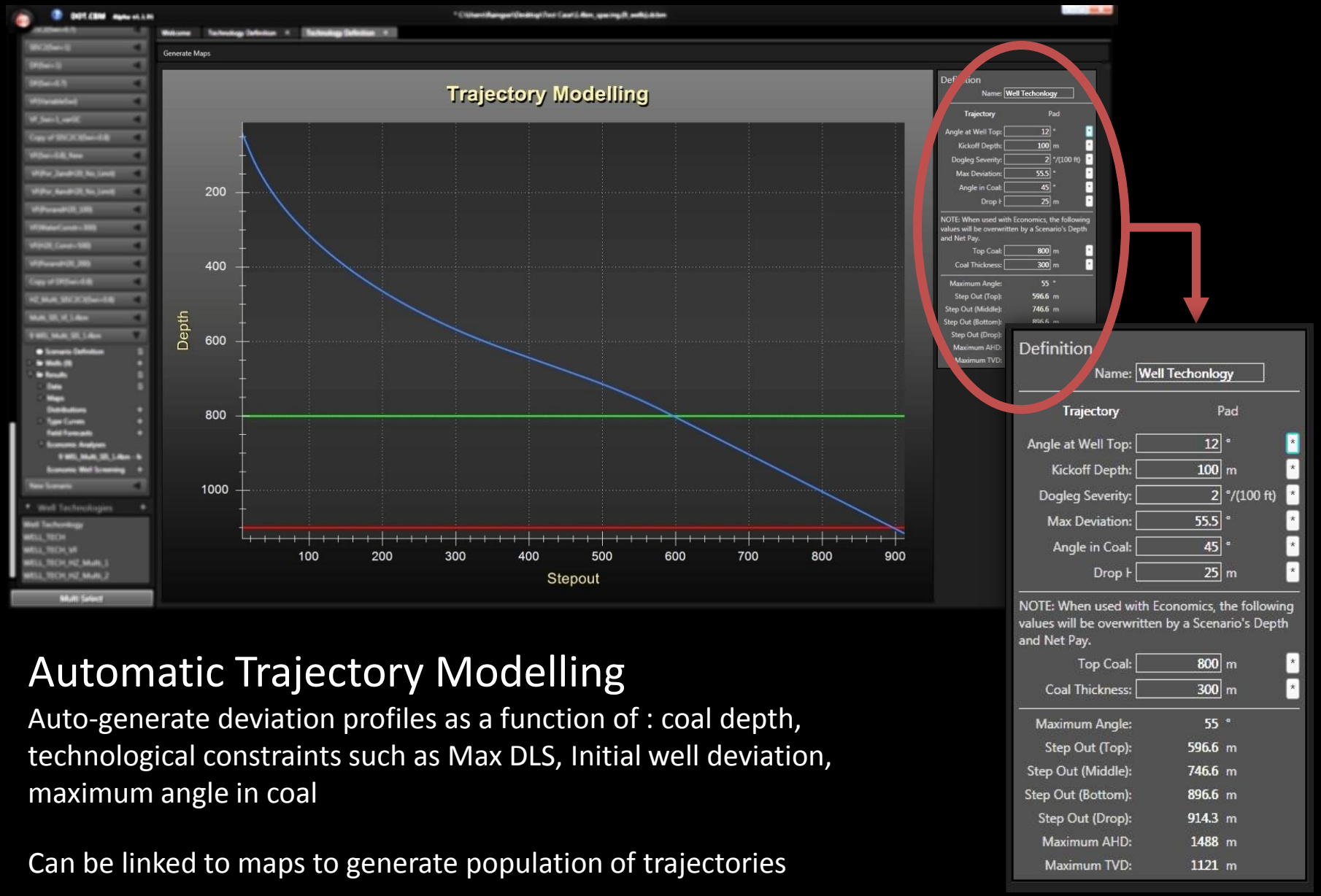


Selection of optimum concept



Well concept modelling

Well technology (trajectory, completion, pad design)



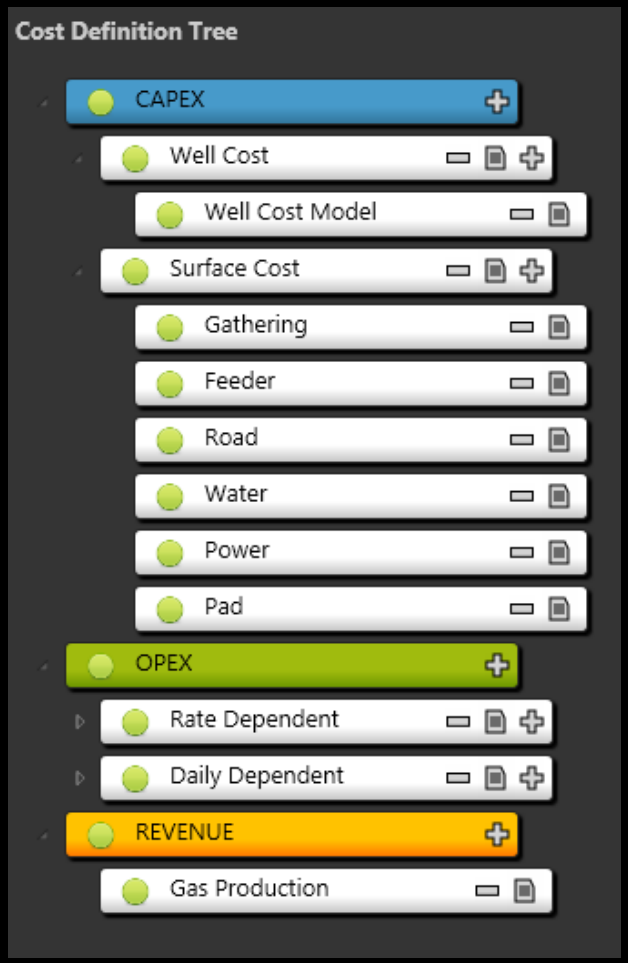
Automatic Trajectory Modelling

Auto-generate deviation profiles as a function of : coal depth, technological constraints such as Max DLS, Initial well deviation, maximum angle in coal

Can be linked to maps to generate population of trajectories

Cost Modelling

Ability to define a comprehensive, as complex as required cost model



Cost Modelling conducted at multi-level

- Child-parent structure allows to capture dependencies
- Powerful ability to link costs to production (ex: Opex $/Mscf/d)

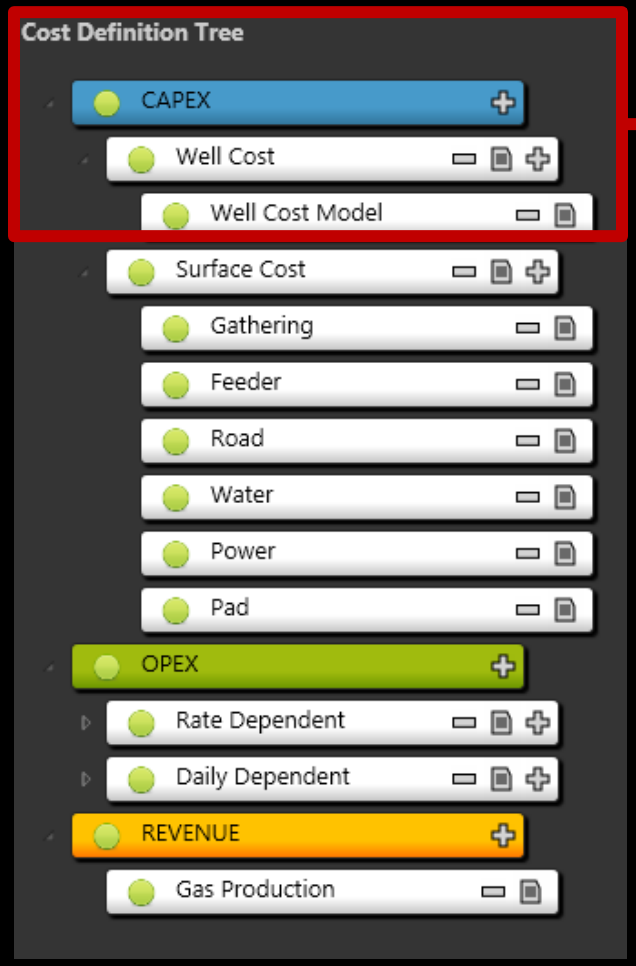
- Full project costs can be included

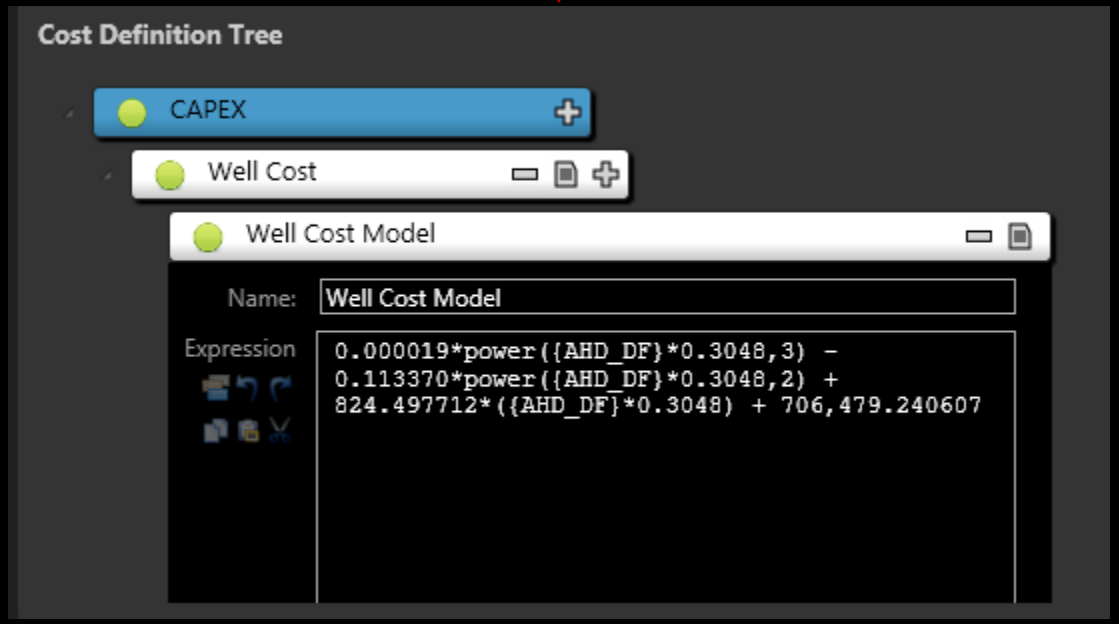
- Designed to screen and support decision making
- Emphasis on comparative capability between concepts

Tax and complex commercial construction not included; this is a concept screening tool rather than a financial planning one.

Cost Modelling

Ability to define a comprehensive, as complex as required cost model

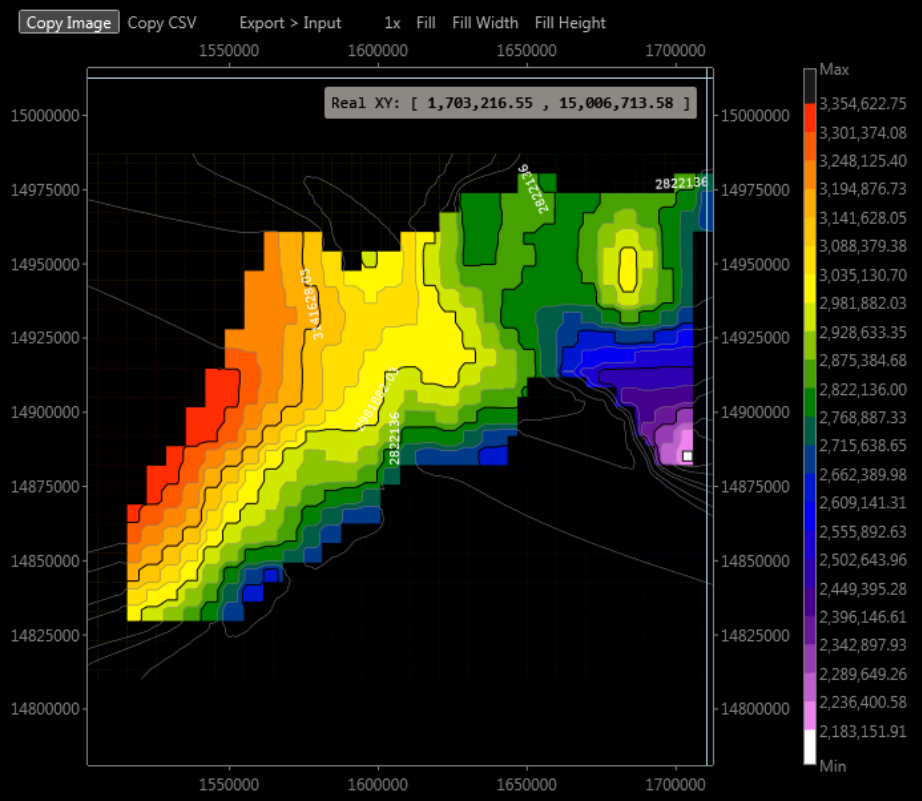




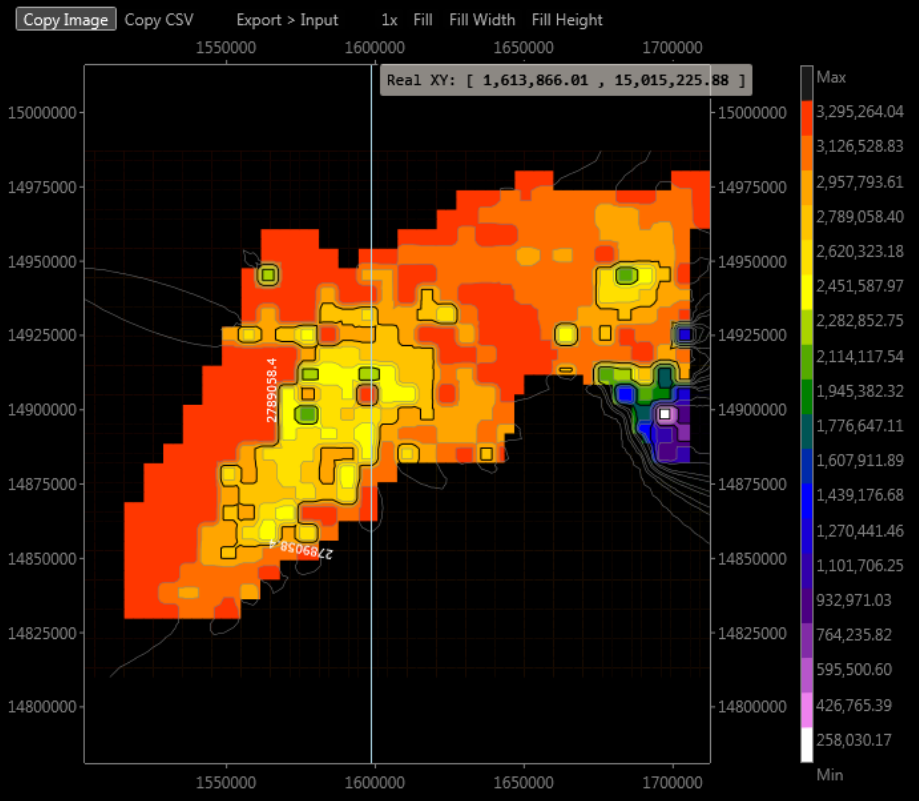
Complex fitting function available for cost modelling

Cost Modelling – areal mapping

Ability to show areal distribution of well and facilities costs on a map basis



Undiscounted CAPEX

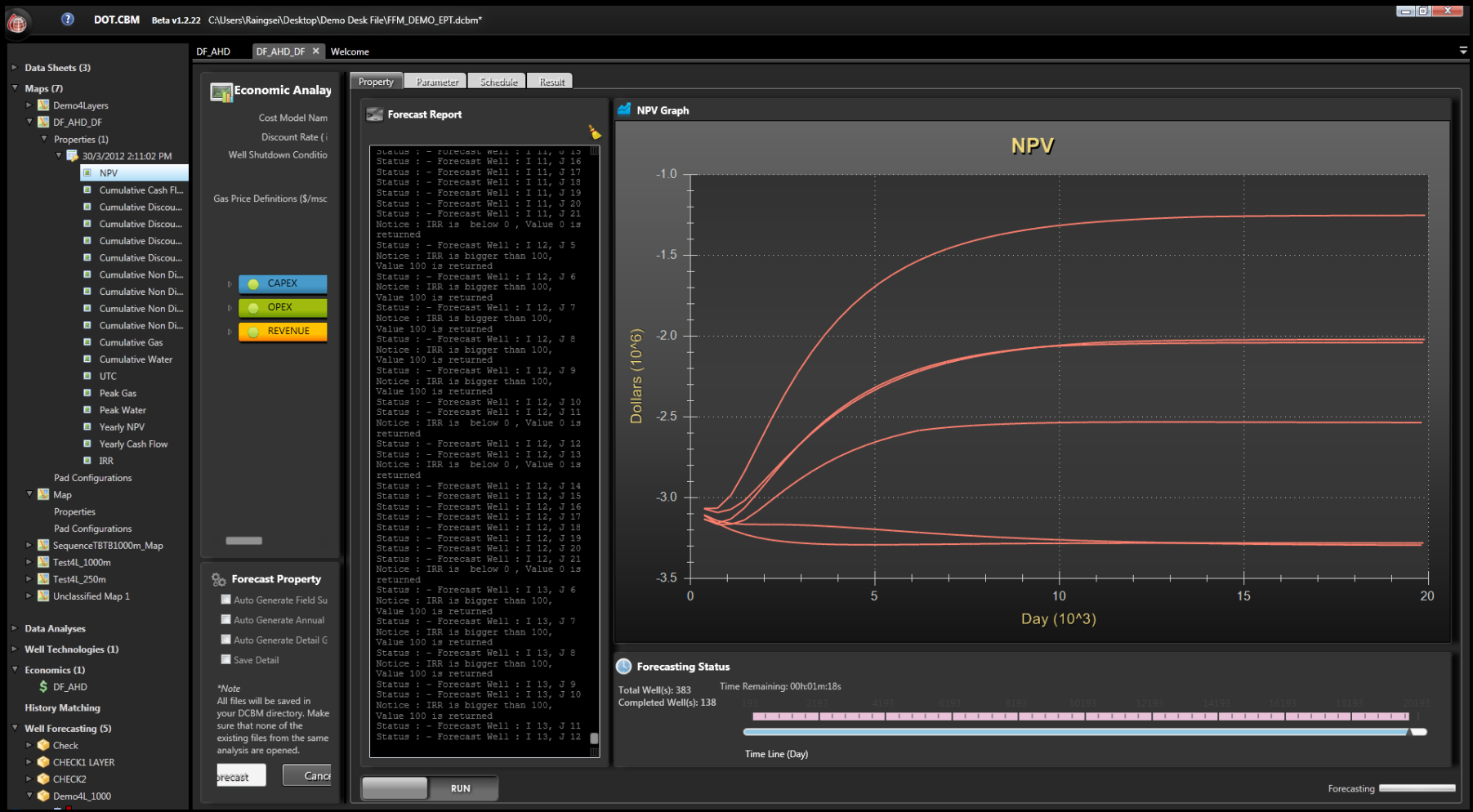


Undiscounted OPEX

Economics: screening

Perform economic calculations, allocated back to each well

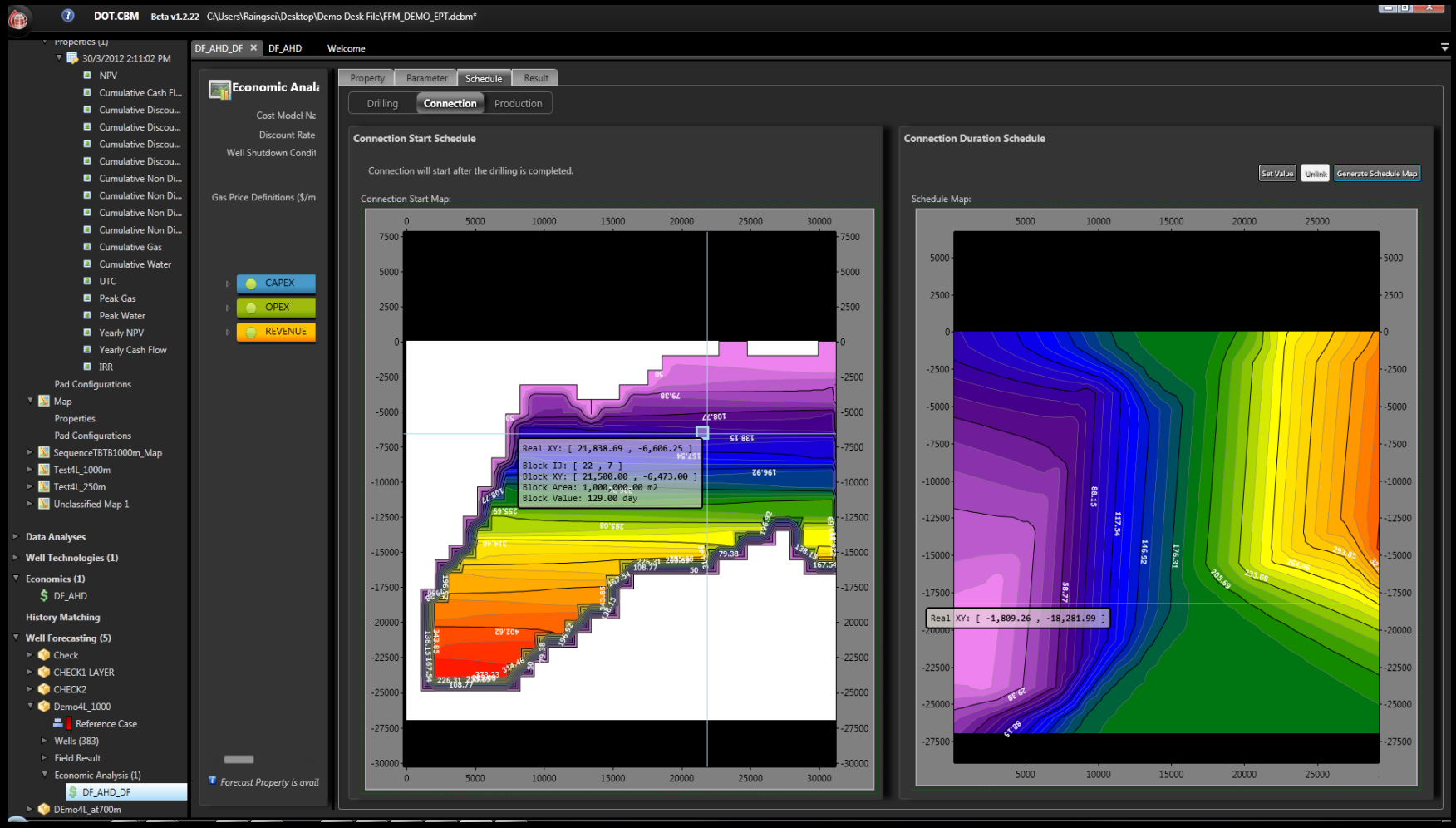
Calculation of multiple indexes (NPV, UTC, IRR etc..) – at well, sector and field level



Full project economics

Requires to generate a field drilling, connection and production sequence

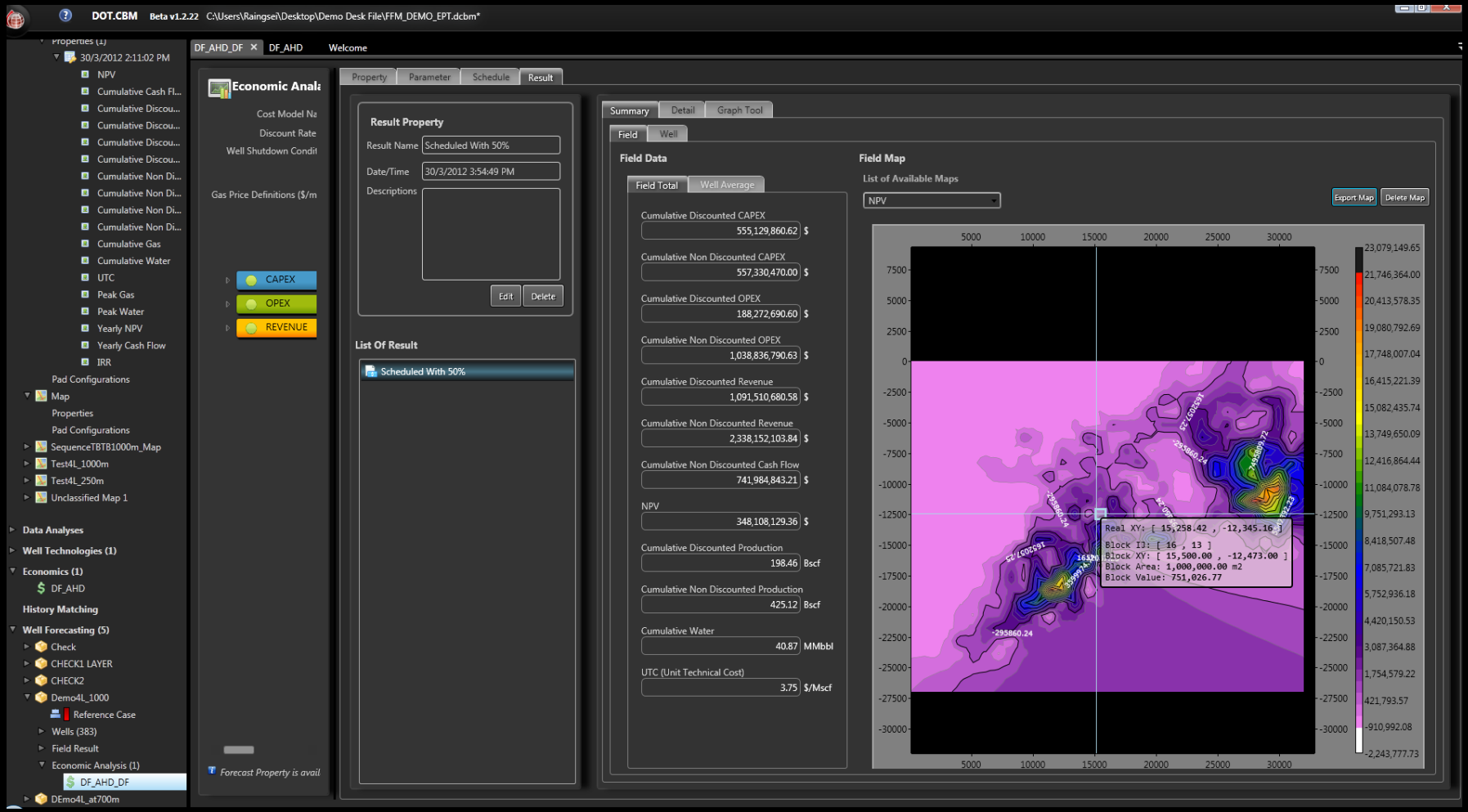
Mapping the drilling, connection and production sequences



Economics: screening and high-grading

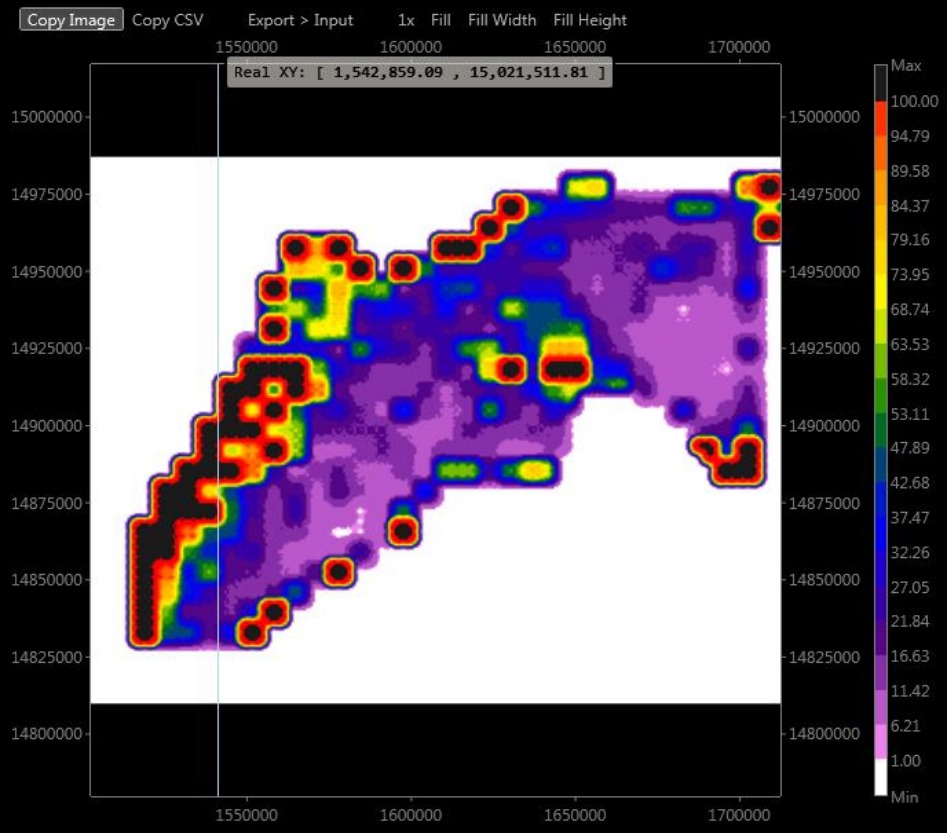
Perform economic calculations, allocated back to each well

Area NPV assessment : HIGH-GRADING

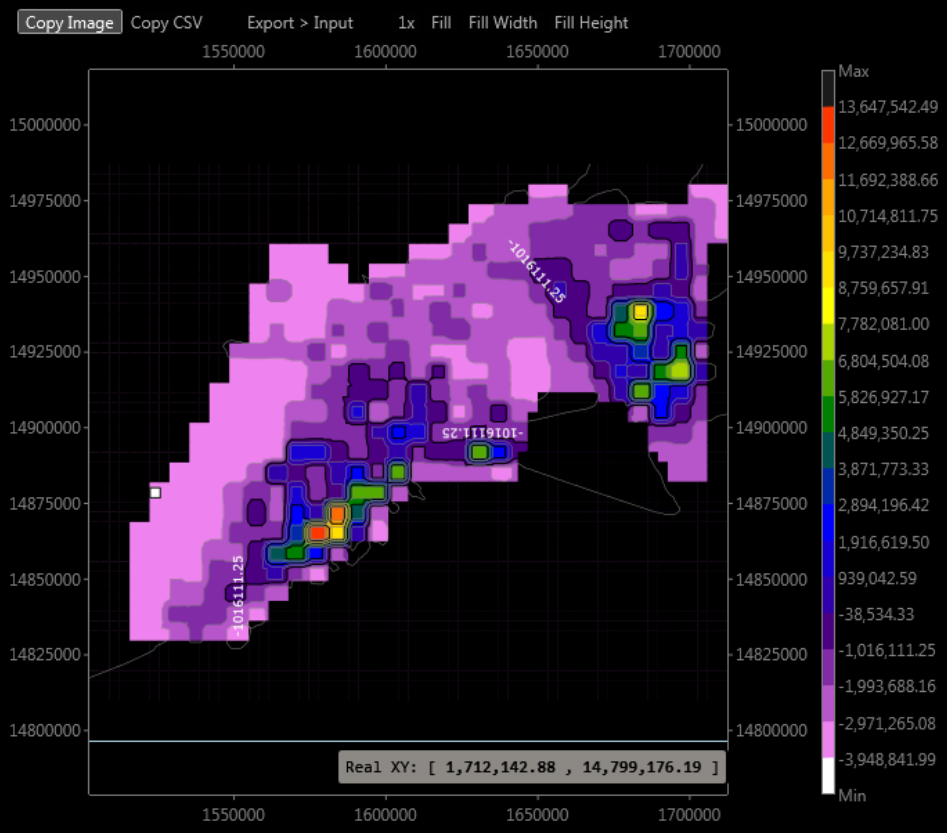


Economic results – areal mapping

This can be used as a basis for field optimisation



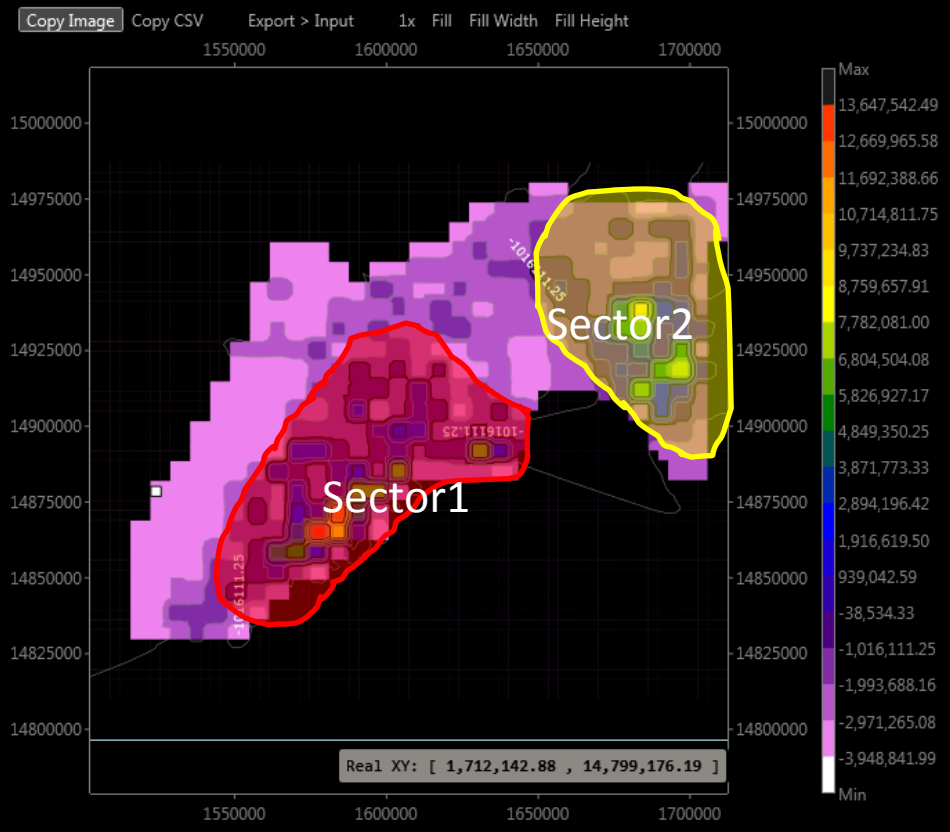
UTC $/Mscf

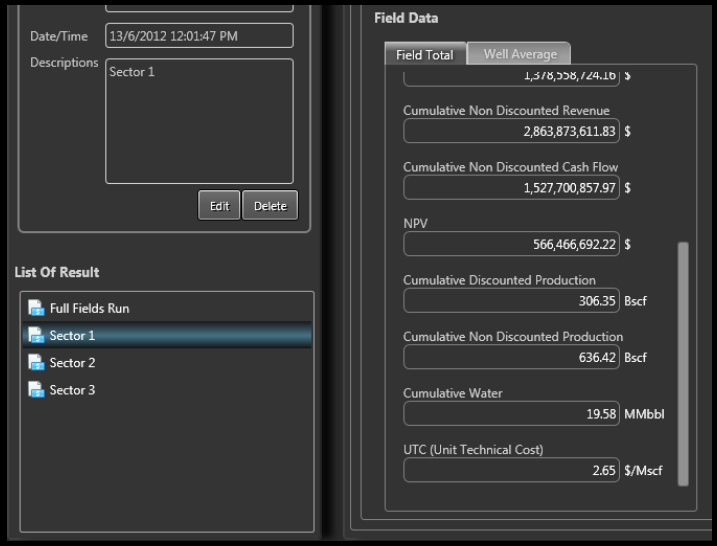


NPV ($)

Sectorisation workflow

Using map based forecast, coupled with Economics



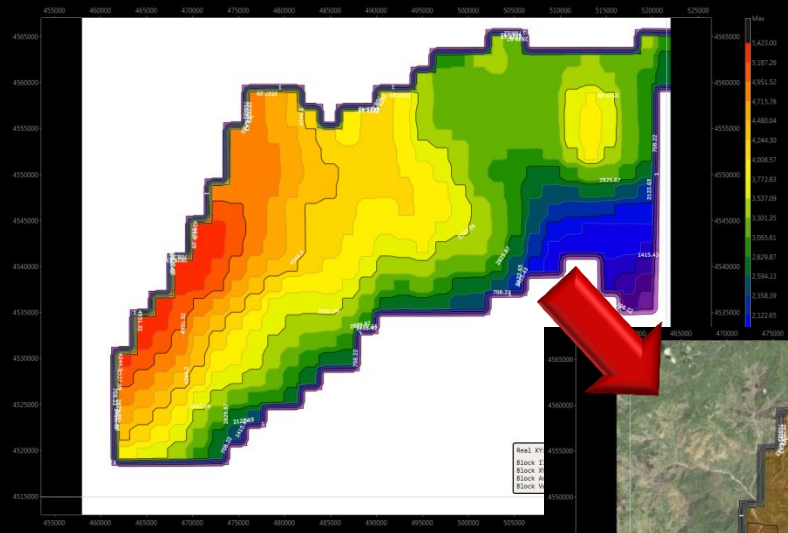


Sector economics are calculated and can be compared to field average

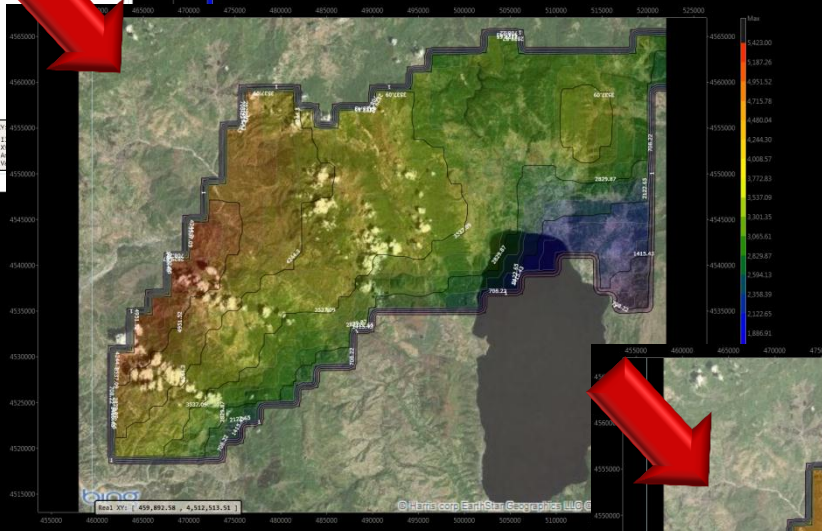
SECTORISATION WORKFLOW

GIS and satellite imaging capability

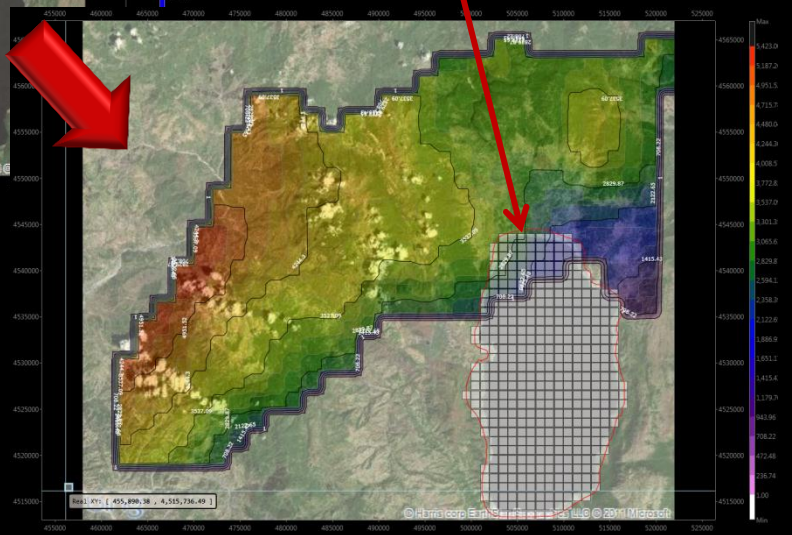
Define avoidance zones for realistic surface developments



Subsurface and surface maps can be coupled with satellite images (GIS), cadastral maps, etc.
Various information layers (e.g. roads, buildings, national parks, etc.) can be added



Restricted/high access cost zones (selected grids)



Surface access restriction zones (cities, mountains, lake, etc.) can be selected based on the available information

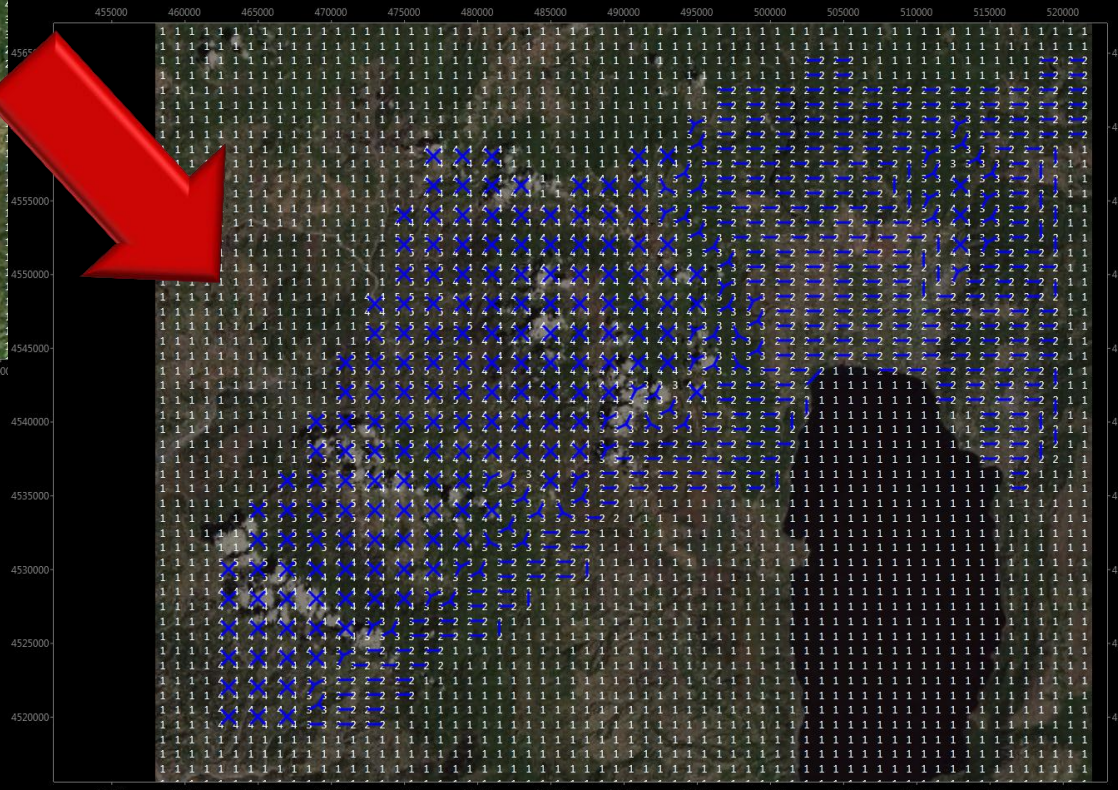
Reflect the influence of surface constraints onto development scheme and its value : cost model, well count etc..

Pad modelling

Pad sizing and pad location selection/optimization

Maximum number of wells per pad is identified based on well concept modelling module.

Number of pads and their locations can be easily selected



FUTURE RELEASE

Optimisation of surface layout based on cost structure

DOT.CBM™

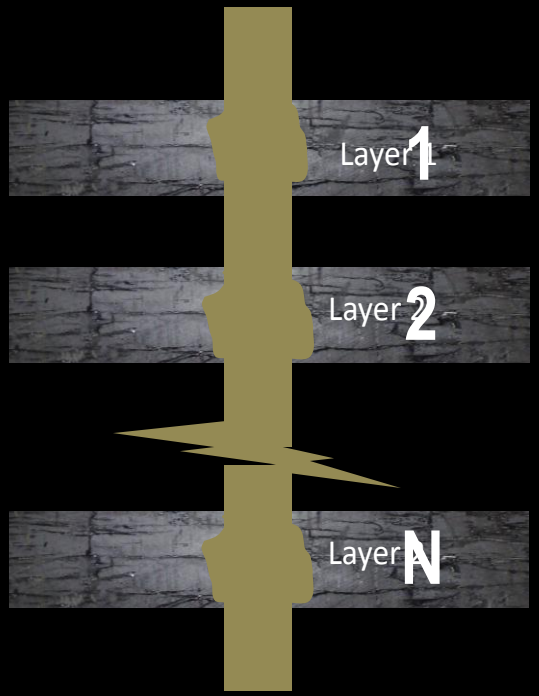
Development Optimization Toolkit for CBM

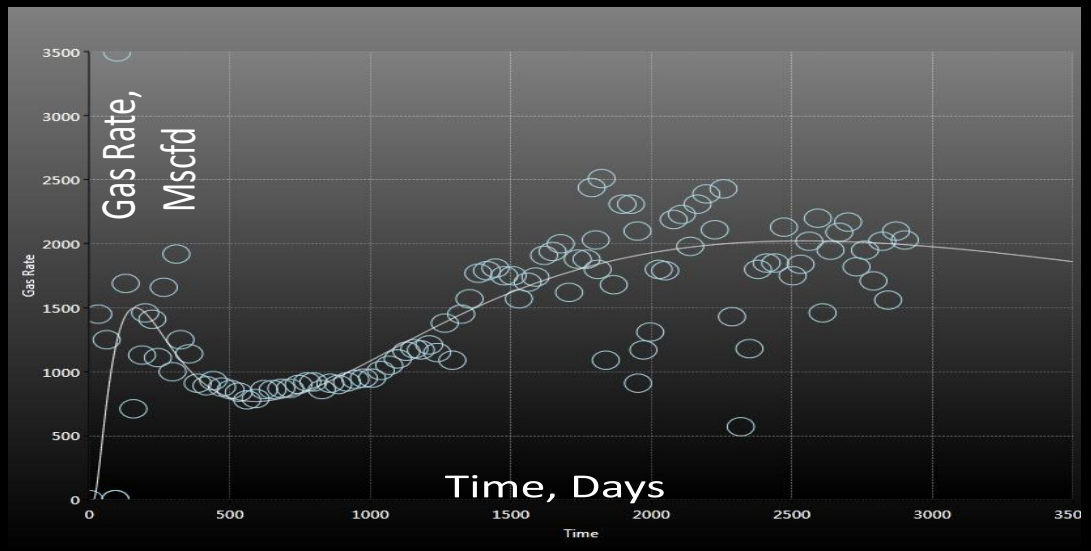
HISTORY MATCHING

Assisted Stochastic History Matching

Advanced solution developed specifically for CBM well history matching

- Rapidly generate a comprehensive range of solutions matching production data
- All reservoir parameters can be varied -solves with 10+ varying parameters per layer
- Investigate and understand multi-layer behaviour
- Numerical Finite Elements and Material Balance models available
- Multiple coupled evolutionary search algorithms

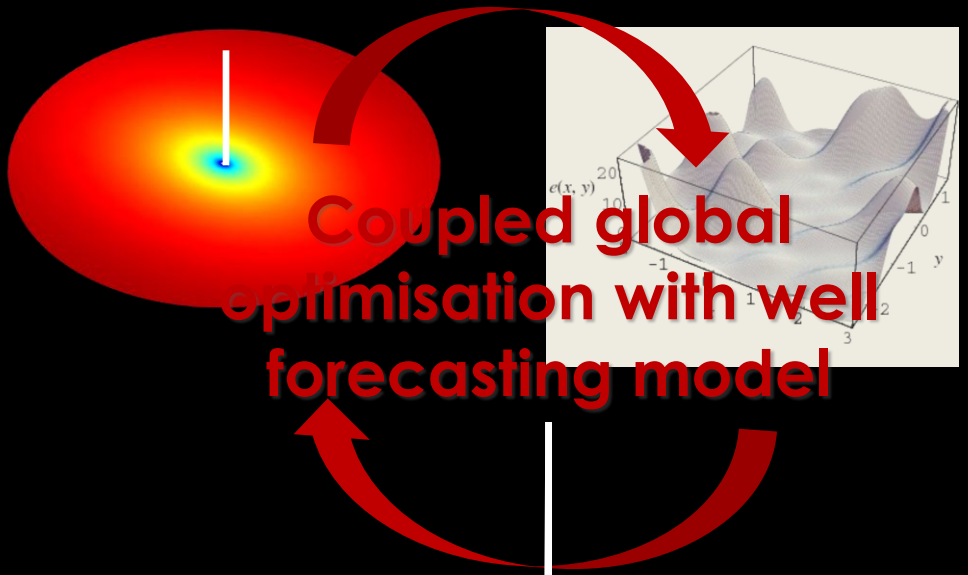




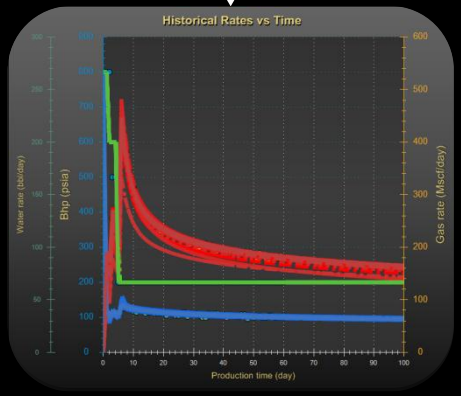
Multiple solutions fitting the historical production

Stochastic History Matching

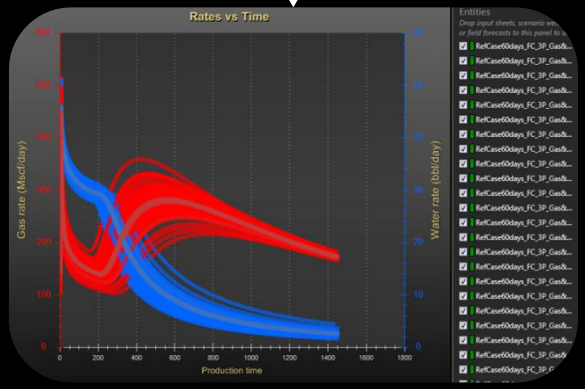
Process allows for 100's of matching cases to be generated in minutes



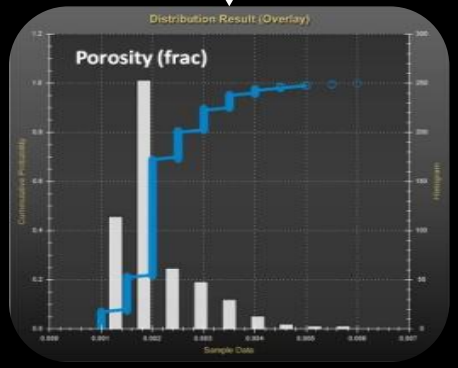
Generate multiple matching realisations



Forecast multiple realisations to assess remaining uncertainty



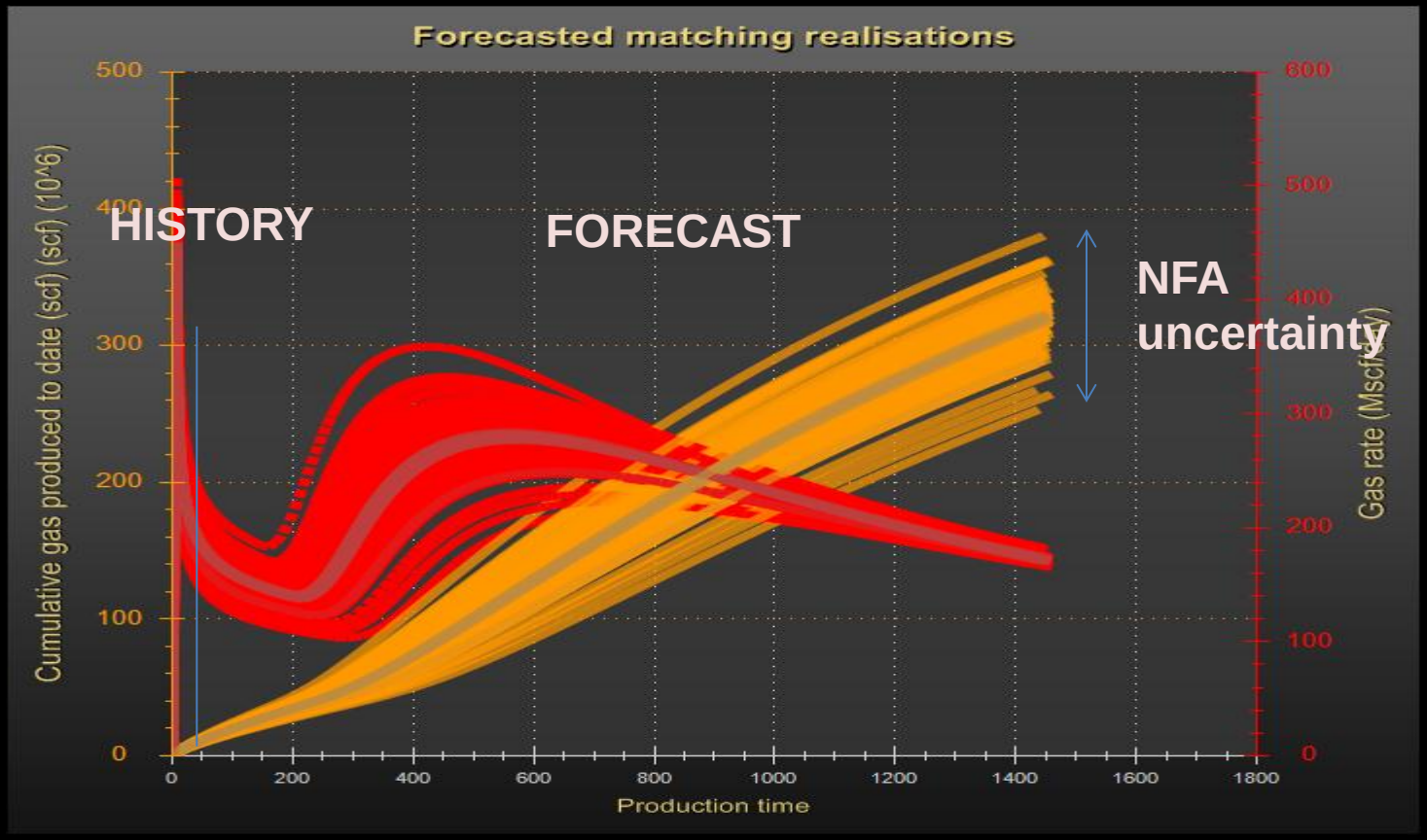
Understand the underlying matching parameter ranges



Forecasted matched models

Generate a range of forecasts based on alternative matching realisations

- Rapid assessment of the residual uncertainty associated with NFA forecast
- Identification of remaining potential in NFA and further-activity case

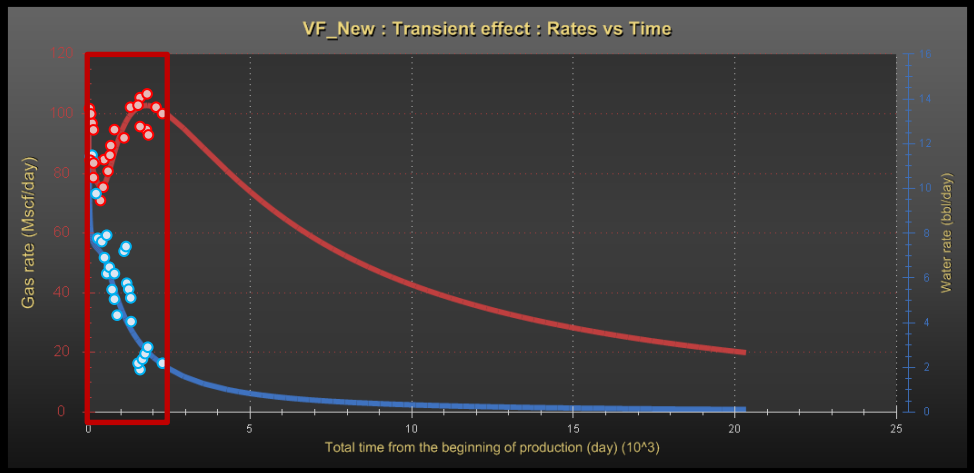


History Matching

Two approaches

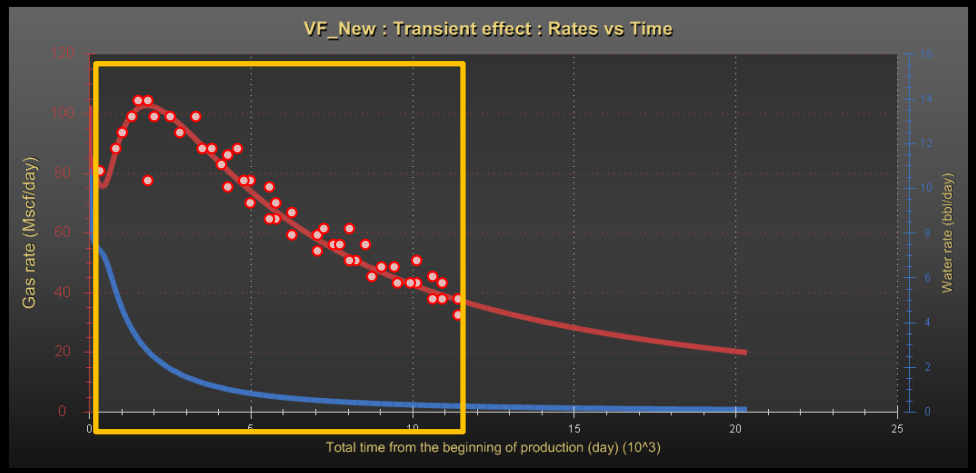
Short-term pilot production (1-6months)

Especially tighter coals (<5mD)
Use Finite Element (numerical) model
Captures early production time effects



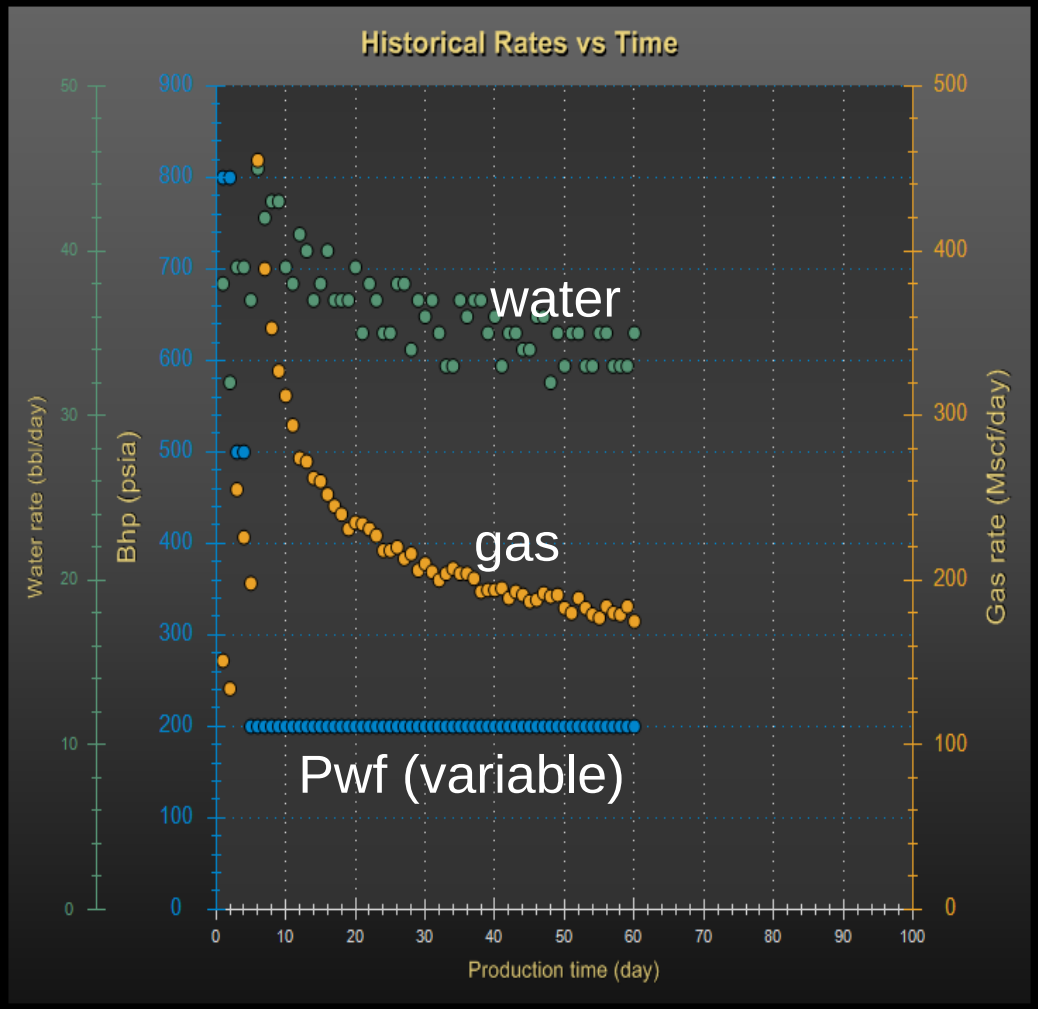
Mid/Long-term pilot production (6-24+ months)

Emphasis on matching later time production profile
Use Material balance forecast



Pilot production matching

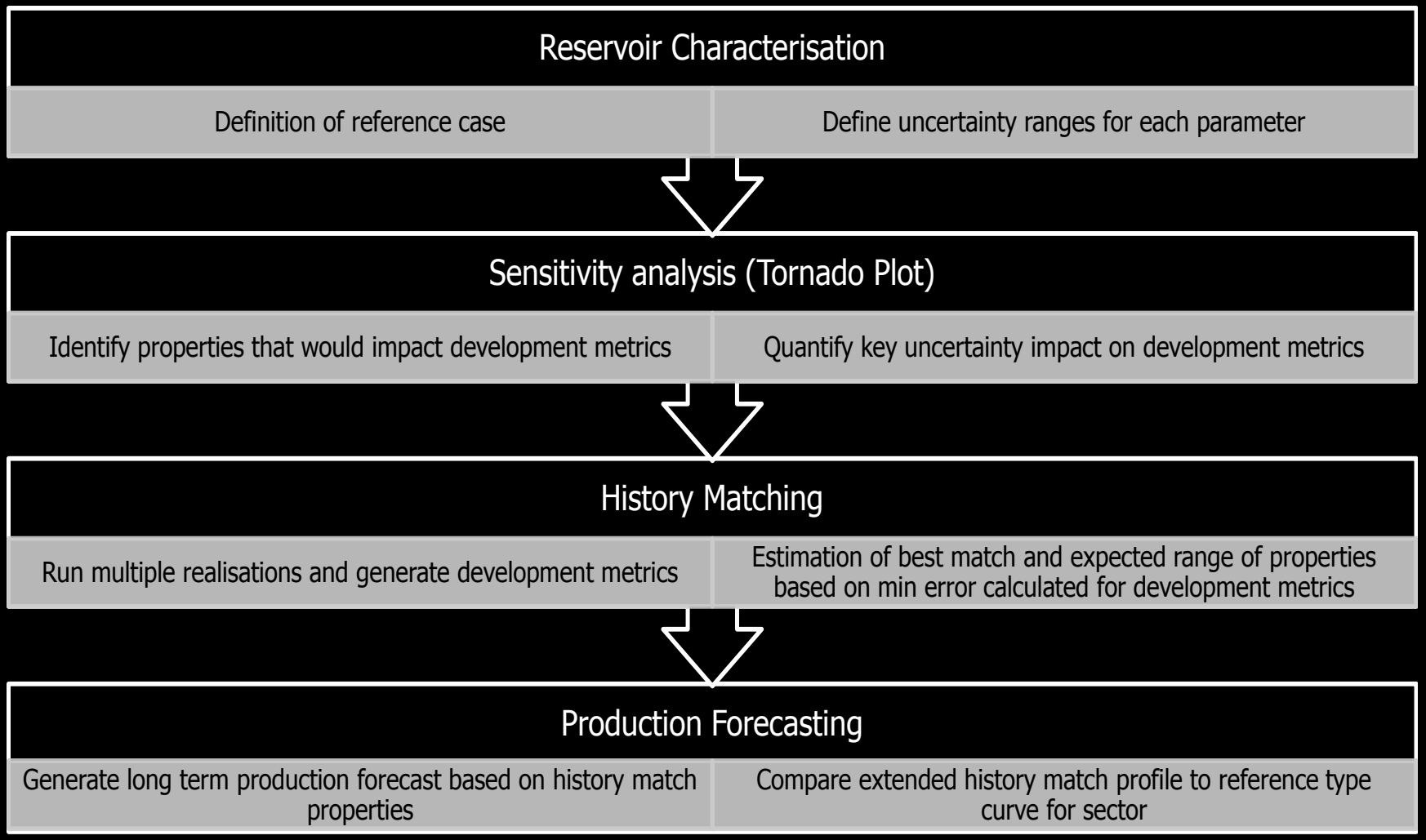
Typical problem faced by CSG operators



- **Limited availability of data such as:**
  - Isotherm, gas content
  - Permeability, porosity
- **Production data desired to understand better reservoir parameters and future production potential of wells**
- **But:**
  - Extended, continuous production is a problem for various reasons
  - Ambiguity in the collected production data

Pilot production matching

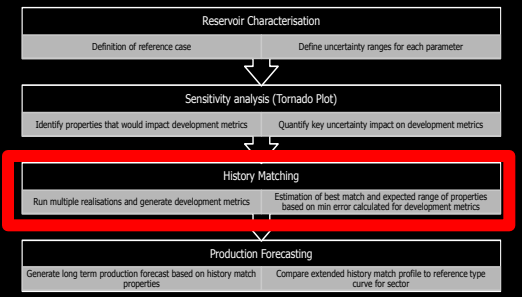
Our Workflow for the assesment of early production pilots



Pilot production matching

Our Workflow for the assesment of pilot production

History Matching
Non-unique solutions



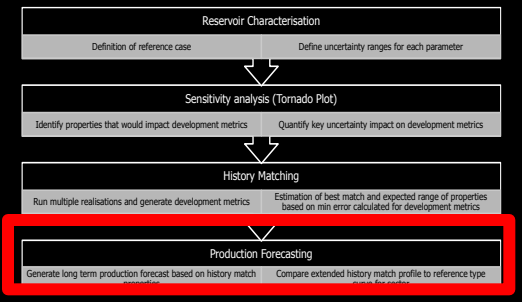
Zoom on total runs:

12,000++ cases run in 1 minute.

Pilot production matching

Our Workflow for the assesment of pilot production

Forecasting Multi-realisations

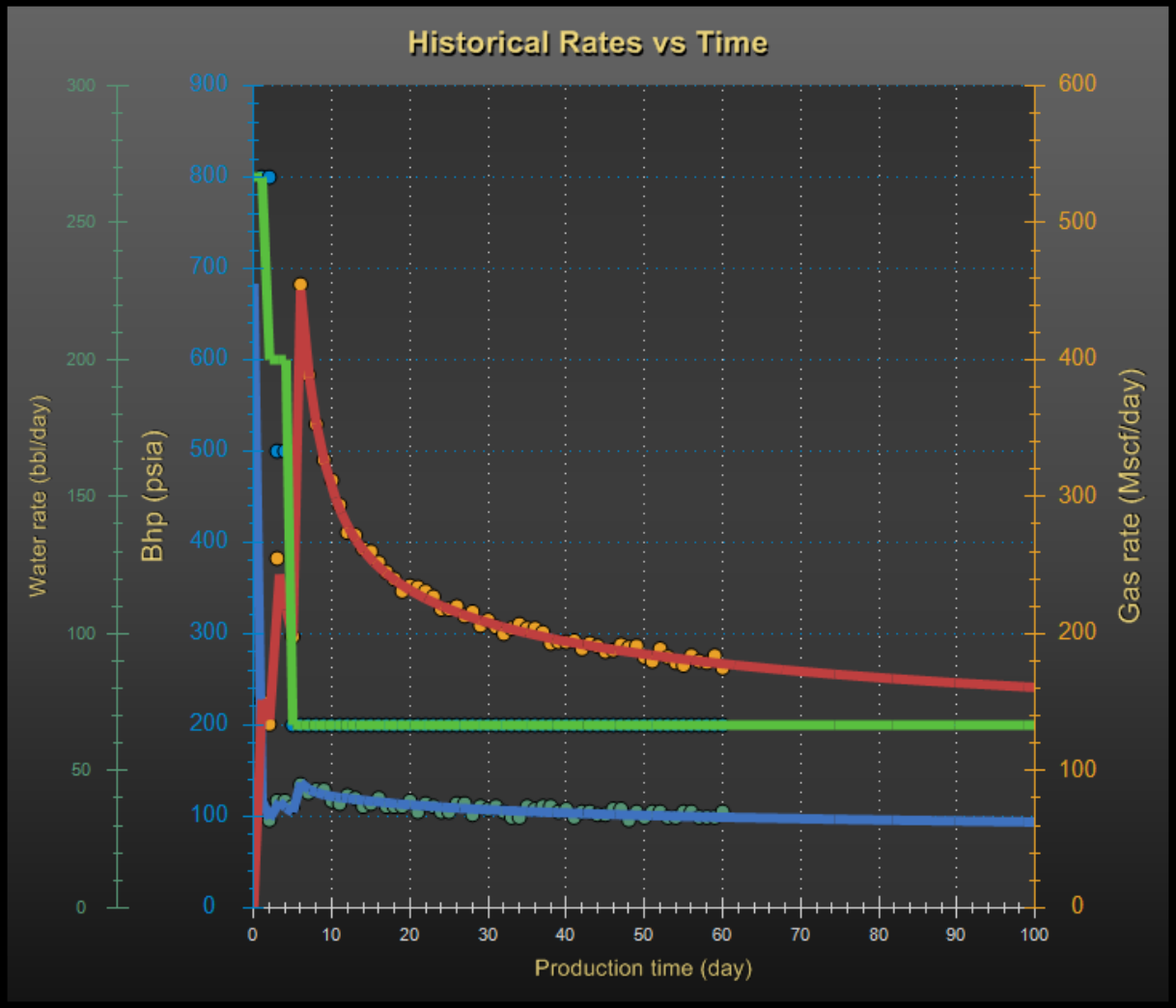


Why match multi-realisations and then forecast them ?

Isn’t one match good enough…?

Pilot production matching

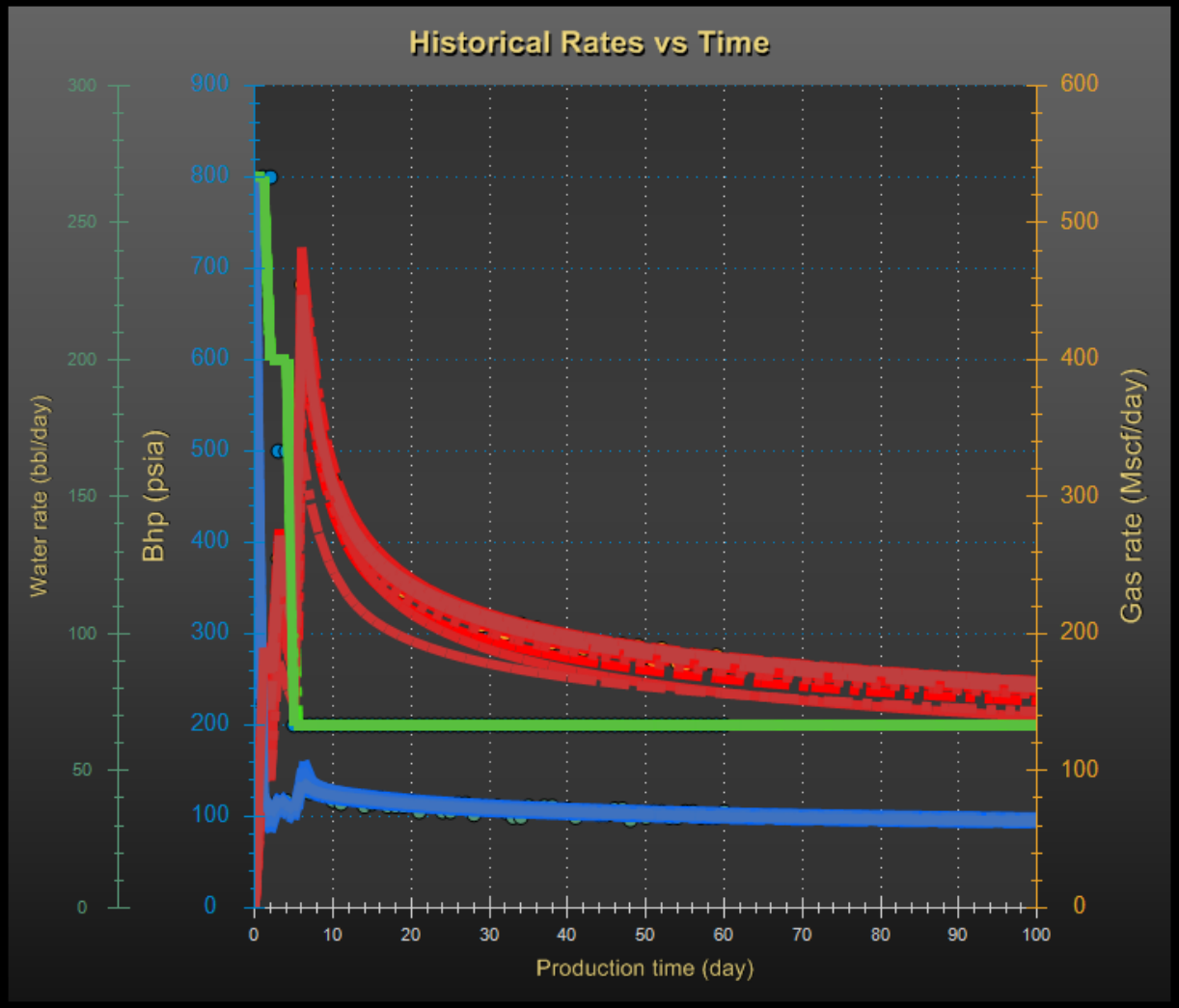
Example of multi-parameter matching



- Single well match and it's forecast
- Useful but is this the only solution?
- Given the uncertainty on CSG reservoir characteristics

Pilot production matching

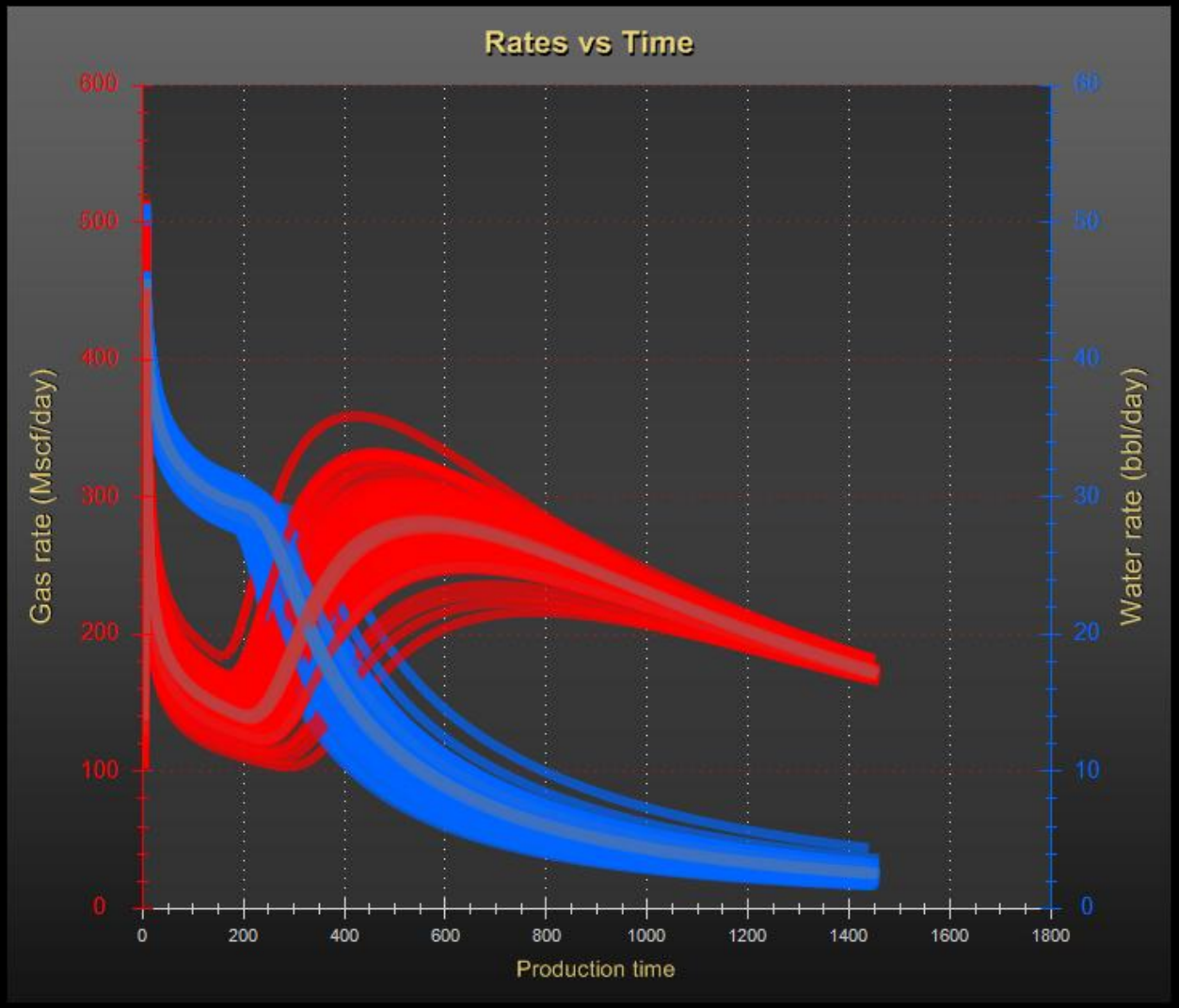
Example of multi-parameter matching



- A few selected additional matches
- Evidence of a range of possible future performance given an acceptable historical match

Pilot production matching

Example of multi-parameter matching



Now plotting the top 150 solutions

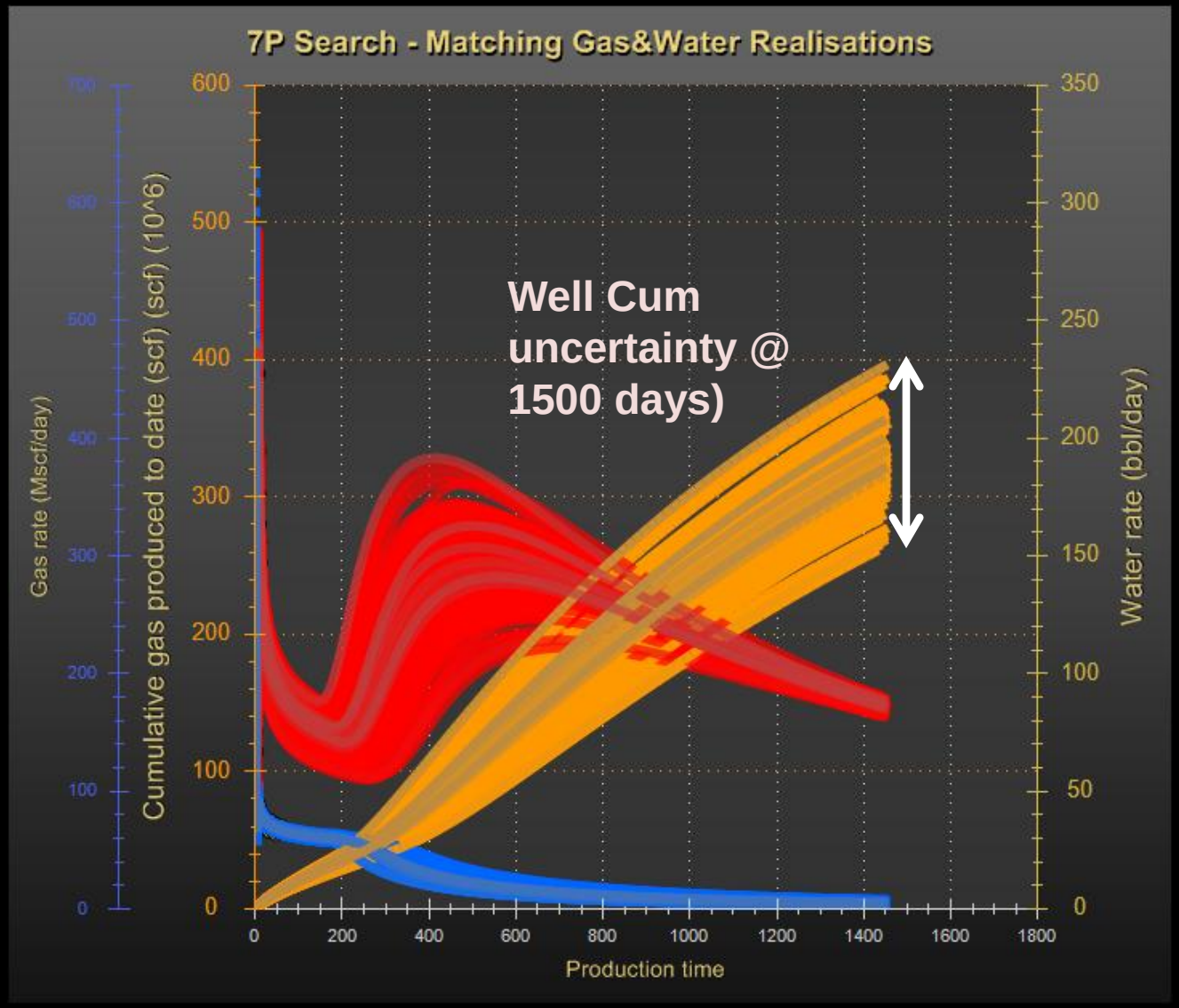
Selected as acceptable match

Provides a greater understanding of

- Future well performance
- Underlying reservoir parameters

Pilot production matching

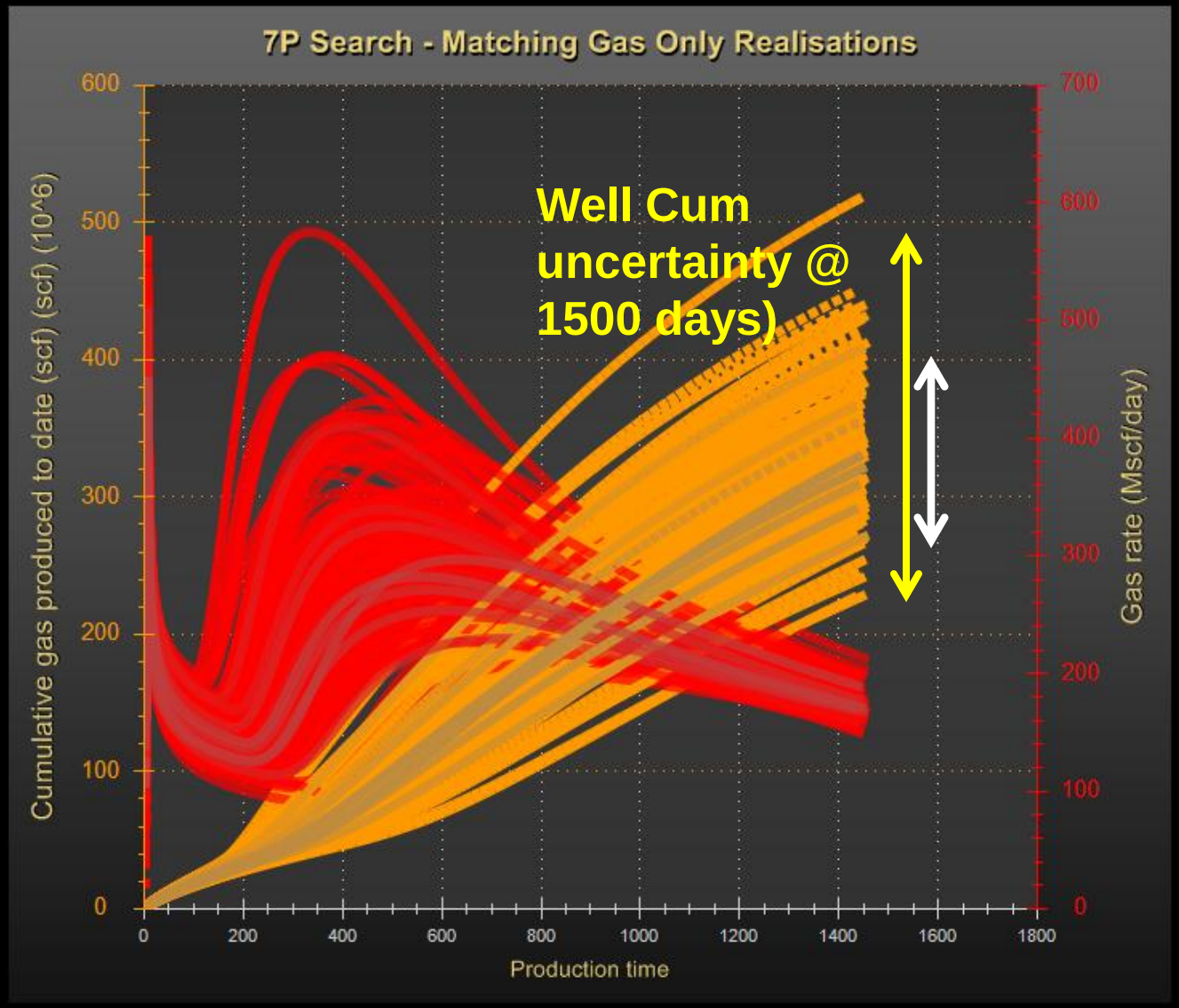
Value of Information for Water Measurement at well level



- **Remaining uncertainty can be quantified**
- **Useful for reserves assessment**

Pilot production matching

Value of Information for Water Measurement at well level



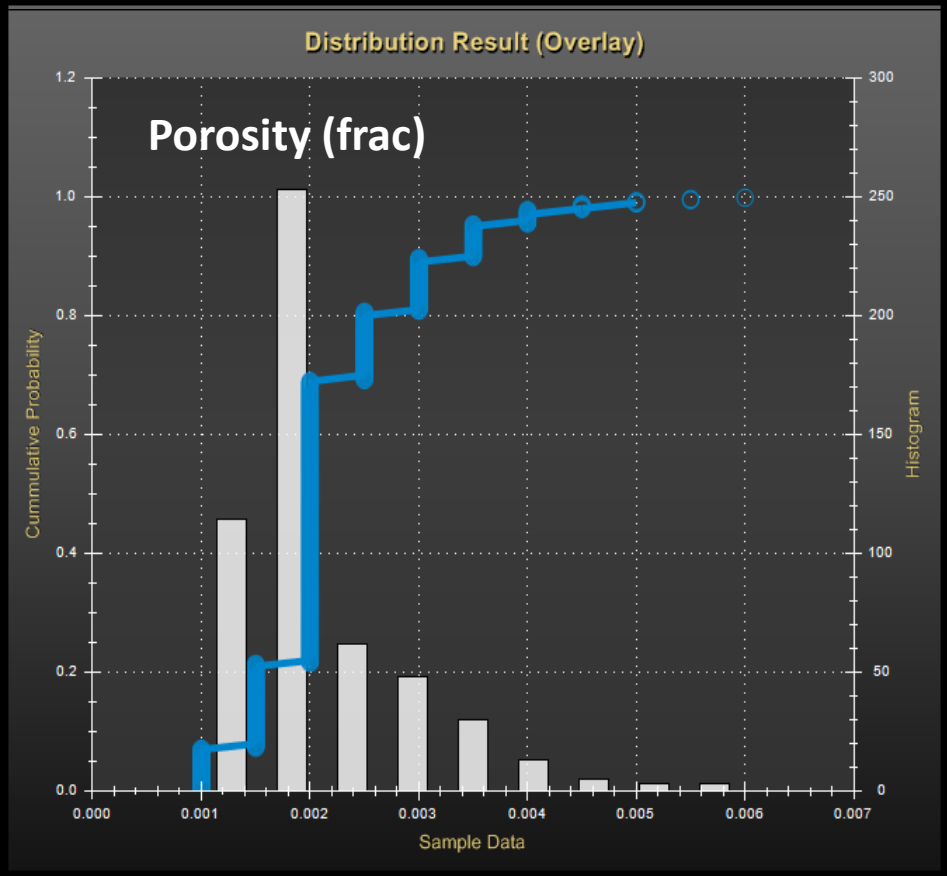
- **Considerable Value of Information associated to measuring individual well water production**
- **The stochastic workflow allows to quantify the information**

Pilot production matching

Utilising the matched cases to extract statistics: MATCHING PARAMETERS

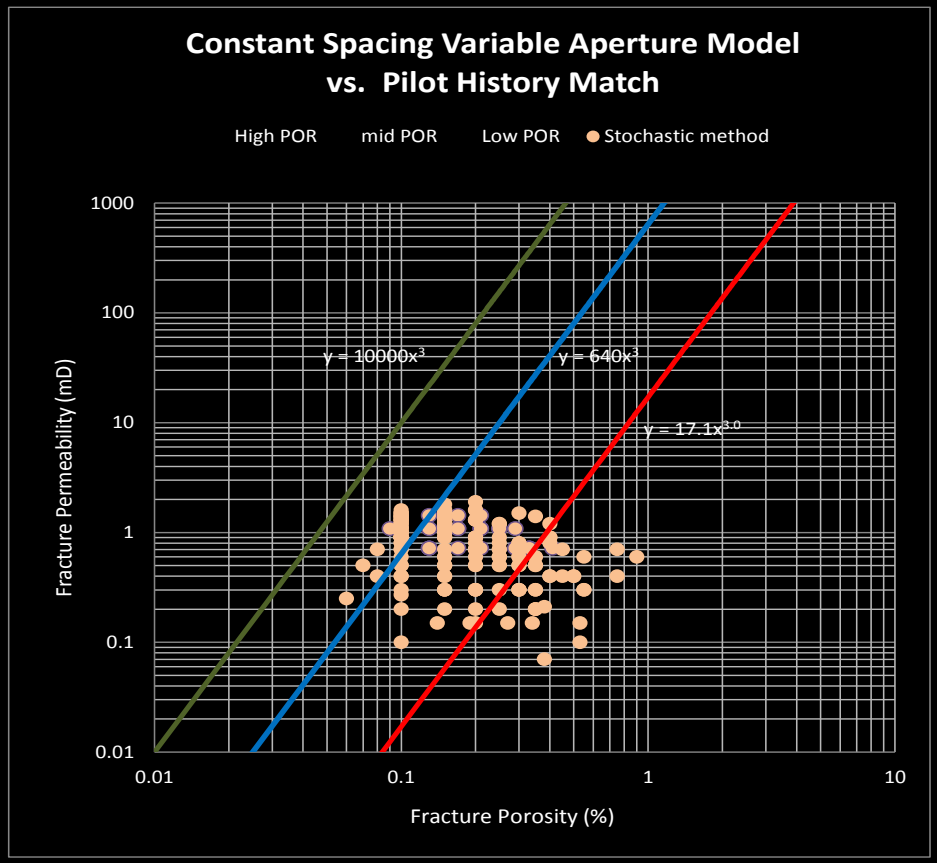
Reservoir characteristics

Assess uncertainty range in match
given data quality and production time



Cross-plot results

Verification of reservoir characterisation
models vs. Solutions from HM

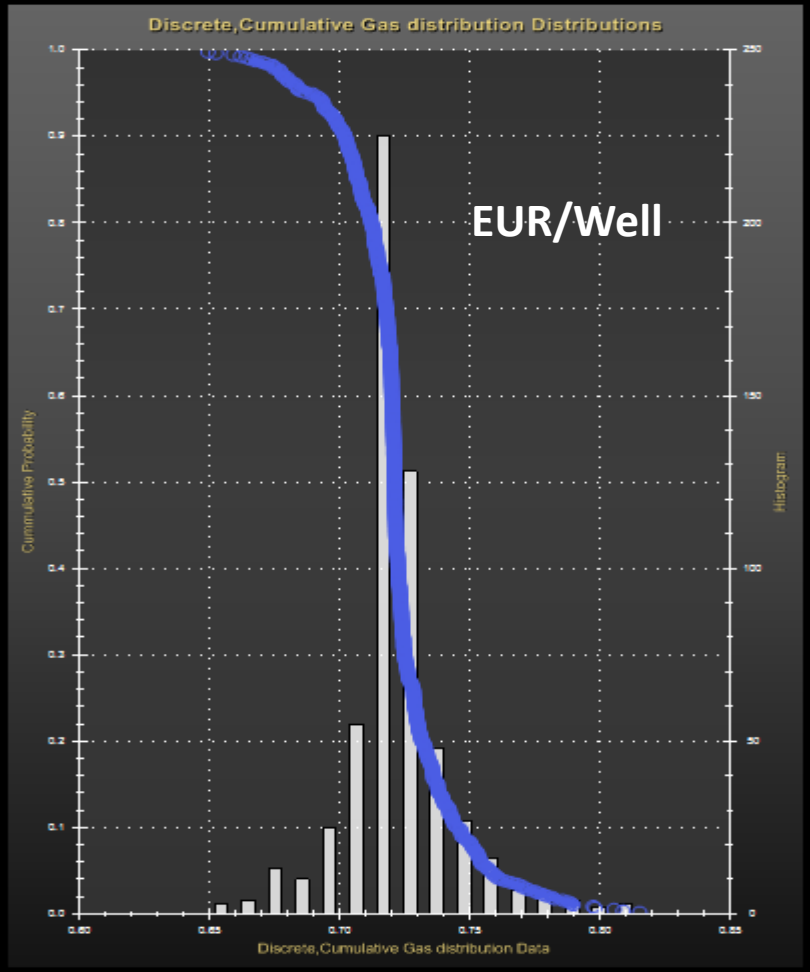


Pilot production matching

Utilising the matched cases to extract statistics: FORECAST RESULTS

Statistics on matches

Again we use the DOT.CBM data analysis capability

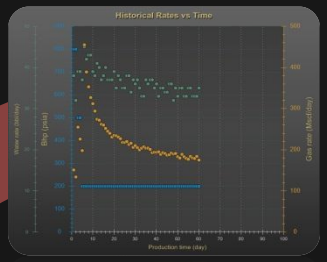


Multi-Well History Matching

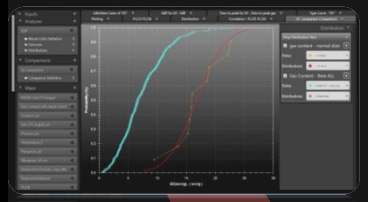
Matches Filtering & Average Maps Generation

Well Level

Production Data



Reservoir Characterization



Single Well History Matches

Field Level

Field Matches Filtering

#	Perm	Area	Porosity	Gci	VI
1	0.1739	338	0.0251	353	649
2	0.2599	123	0.0033	542	934
3	0.2437	2	0.042	230	778
4	0.0668	142	0.0043	339	651
5	0.2409	18	0.0495	549	789
6	0.1141	31	0.0058	216	648
7	0.1225	380	0.0012	180	729
8	0.043	296	0.001	280	751
9	0.1389	50	0.0005	235	662

#	Perm	Area	Porosity	Gci	VI
1	0.1739	338	0.0251	353	649
2	0.2599	123	0.0033	542	934
3	0.2437	2	0.042	230	778
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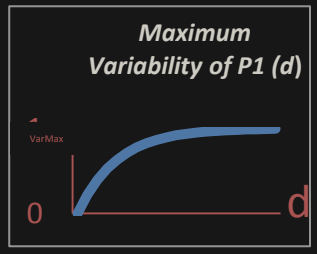
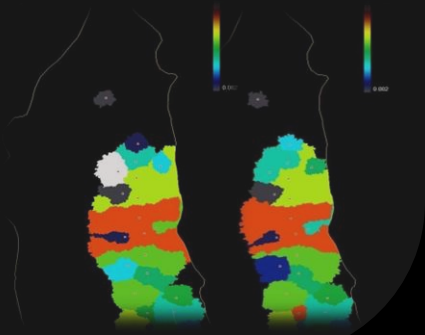
7	0.1225	380	0.0012	180	729
8	0.043	296	0.001	280	751
9	0.1389	50	0.0005	235	662

Geo-statistical Constraints



Average Properties Maps



Field Matches Filtering

Using Geo-Statistical Constraints

Possible Matches for Well1

#	Perm	Area	Porosity	Gci	VI
1	0.1739	338	0.0251	353	649
2	0.2599	123	0.0033	542	934
3	0.2437	2	0.042	230	778
4	0.0668	142	0.0043	339	651
5	0.2409	18	0.0495	549	789
6	0.1141	31	0.0058	216	648
7	0.1225	380	0.0012	180	729
8	0.043	296	0.001	280	751
9	0.1389	50	0.0005	235	662

. . . .

Possible Matches for Well i

#	Perm	Area	Porosity	Gci	VI
1	0.1739	338	0.0251	353	649
2	0.2599	123	0.0033	542	934
3	0.2437	2	0.042	230	778
4	0.0668	142	0.0043	339	651
5	0.2409	18	0.0495	549	789
6	0.1141	31	0.0058	216	648
7	0.1225	380	0.0012	180	729
8	0.043	296	0.001	280	751
9	0.1389	50	0.0005	235	662

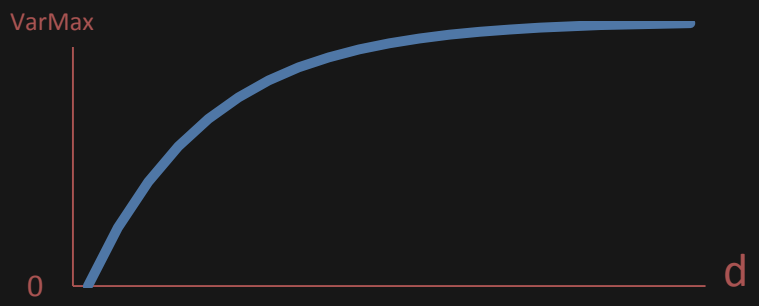
. . . .

Possible Matches for Well n

#	Perm	Area	Porosity	Gci	VI
1	0.1739	338	0.0251	353	649
2	0.2599	123	0.0033	542	934
3	0.2437	2	0.042	230	778
4	0.0668	142	0.0043	339	651
5	0.2409	18	0.0495	549	789
6	0.1141	31	0.0058	216	648
7	0.1225	380	0.0012	180	729
8	0.043	296	0.001	280	751
9	0.1389	50	0.0005	235	662

Geo-statistical Constraints

Maximum Variability of P1 (d)



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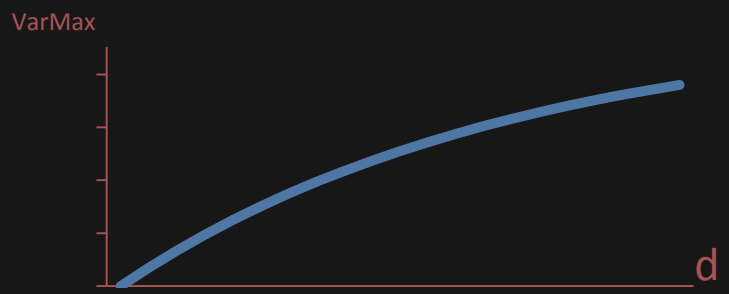
Maximum Variability of Pn (d)

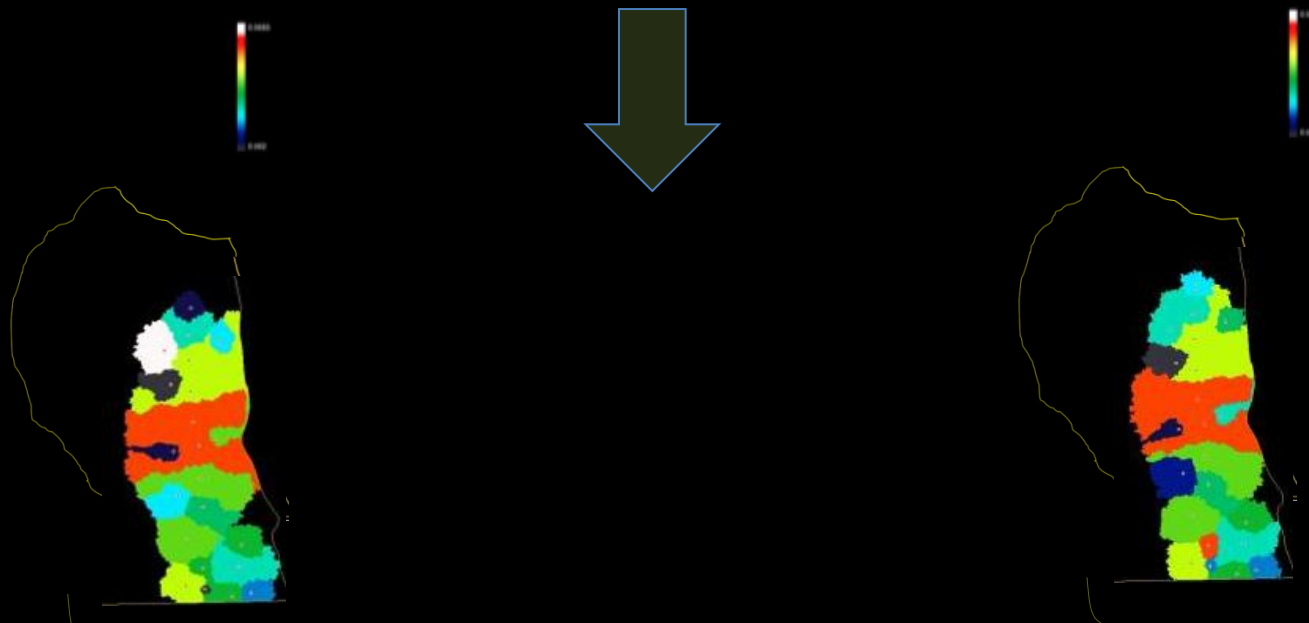


Average Maps Generation

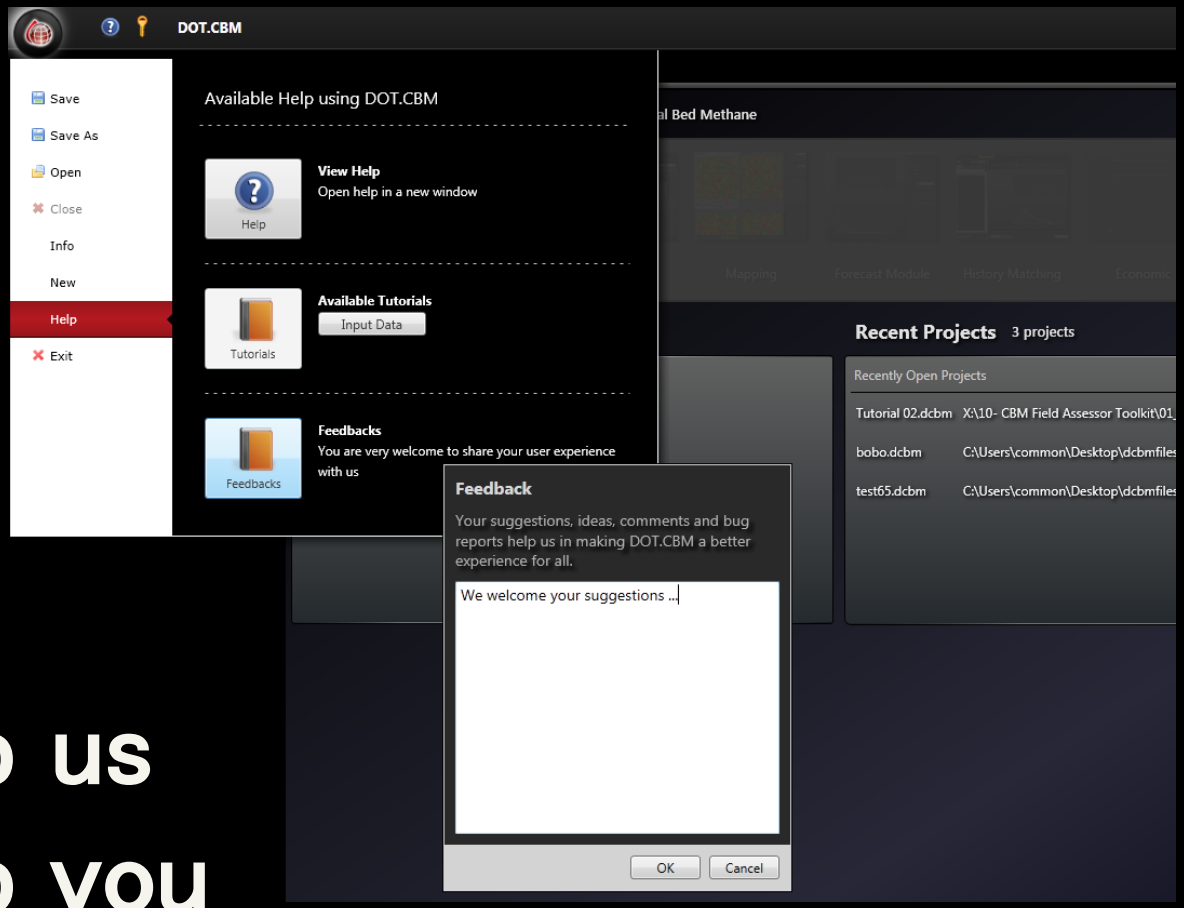
Using Matched Drainage Areas

Field Match 1					
	Well1	Well2	Well3	.	.
Area	100	120	300		
.	.	.	.		
Porosity	0.0008	0.0014	0.002		
.	.	.	.		
Perm	1	2	4		

Field Match 2					
	Well1	Well2	Well3	.	.
Area	150	120	280		
.	.	.	.		
Porosity	0.0007	0.0004	0.0018		
.	.	.	.		
Perm	1	2	4		



Thank you for your attention



Help us
Help you

Share with us your experience, suggestions and ideas with the DOT.CBM feedback tool.